TRACE METAL CONCENTRATIONS IN

THE OFFSHORE WATERS OF LAKES ERIE AND MICHIGAN

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ABSTRACT

During 1981, water samples were collected from ten Lake Erie and ten Lake Michigan stations. Each sample was analyzed for total and dissolved concentrations of silver, aluminum, arsenic, barium, beryllium, bismuth, calcium, cadmium, cobalt, chromium, copper, iron, mercury, potassium, lithium, magnesium, manganese, molybdenum, sodium, nickel, lead, antimony, selenium, tin, strontium, vanadium, and zinc. Observation of the Lake Erie dissolved metal results showed potassium, magnesium, lead, and vanadium to have no regional variation in concentration. Silver, barium, beryllium, calcium, cobalt, lithium, molybdenum, sodium, selenium, and strontium progressively increased from west to east. Aluminum, bismuth, cadmium, chromium, copper, iron, mercury, manganese, nickel, and zinc concentrations were lowest in the central basin. Tin increased from east to west, and antimony and arsenic were highest in the western and central basins of the lake.

Observation of the total metal results showed that magnesium had no distinct regional variation. Bismuth, calcium, molybdenum, and sodium concentrations increased from west to east. Aluminum, barium, mercury, manganese, nickel, lead, tin, vanadium, and zinc increased from east to west. This increase and the occurrence of highest concentrations of aluminum, barium, beryllium, cadmium, cobalt, chromium, copper, iron, mercury, potassium, lithium, manganese, nickel, lead, tin, vanadium, and zinc illustrate results expected when the western basin of Lake Erie is sampled during and immediately after a storm event. Resuspended sediments contributed significant amounts of metals, as particulates, to the measured total metal concentrations.

In general, southern Lake Michigan and Green Bay had the highest dissolved metal concentrations in Lake Michigan, and central Lake Michigan had the lowest concentrations. Green Bay had relatively high aluminum, arsenic, cobalt, chromium, iron, manganese, nickel, tin, and vanadium concentrations. Southern Lake Michigan had relatively high aluminum, mercury, nickel, lead, antimony, selenium, and tin concentrations. Central Lake Michigan had relatively low concentrations of aluminum, beryllium, bismuth, cadmium, cobalt, chromium, iron, nickel, and tin. Metals which were similar in concentration for all regions include silver, barium, calcium, potassium, magnesium, molybdenum, sodium, and strontium.

Green Bay had relatively high total concentrations of aluminum, arsenic, beryllium, cadmium, cobalt, iron, mercury, manganese, and vanadium. It also had the lowest chromium, lead, antimony, selenium, and tin concentrations. Central Lake Michigan was notable for its low silver, aluminum, cobalt, iron, nickel, and lead concentrations. Total metals which displayed little areal variability included barium, calcium, potassium, lithium, magnesium, molybdenum, sodium, strontium, and zinc.

In both Lake Erie and Lake Michigan, large percentages of aluminum, iron, and manganese were associated with particulate matter. A substantial fraction of the total beryllium, cobalt, copper, lead, tin, vanadium, and zinc were associated with Lake Michigan particulate matter. In Lake Erie, a substantial fraction of the total silver, beryllium, chromium, copper, mercury, lead, tin, and vanadium were associated with the particulate fraction. For Lake Michigan and especially Lake Erie, it appears that a significant fraction of the particulates may have been resuspended sediment.

For Lakes Erie and Michigan, most of the identifiable historical trace metal data are of questionable quality. Their utilization for describing changes in metals with time is very limited. All trends derived must be used with caution, especially for assessing the changing health of a Great Lake. In Lake Erie, total arsenic, beryllium, chromium, and mercury and dissolved vanadium concentrations appear to be decreasing; and total barium and dissolved molybdenum concentrations appear to be increasing. In Lake Michigan, dissolved silver, aluminum, chromium, copper, and mercury appear to be decreasing; while dissolved antimony, selenium, and vanadium appear to be increasing.

On occasion, Lake Erie cadmium, copper, iron, and selenium and Lake Michigan silver and selenium concentrations exceeded Water Quality Agreement objectives. In both lakes, the recommended selenium objective was exceeded in 82% of the samples analyzed.

For Lake Erie, silver, cadmium, copper, iron, and selenium significantly contributed to the calculated toxicity unit. For Lake Michigan, silver, cadmium, iron, mercury, and selenium significantly contributed to this unit. The high occurrence of analyzed samples exceeding the recommended selenium objective and selenium's highly significant contribution to the calculated toxicity units warrant careful monitoring of this metal.

TABLE OF CONTENTS

	Page
Disclaimer	ii
Abstract	iii
List of Figures	viii
List of Tables	ix
Acknowledgments	xvii
Introduction	1
Methods	1
Collection	1
Preparation	2
Analyses	2
Limit of Detection	6
Criterion of Detection	8
Blanks	8
Inter-laboratory Comparison	11
Manipulation of STORET Data	11
Results	13
Lake Erie	14
Regional Metal Concentrations	14
Trace Metal Trends	17
Silver (Ag)	19
Aluminum (Al)	19
Arsenic (As)	19
Barium (Ba)	23
Beryllium (Be)	23
Bismuth (Bi)	23
Cadmium (Cd)	23
Cobalt (Co)	28
Chromium (Cr)	28
Copper (Cu)	28
Iron (Fe)	33
Mercury (Hg)	33
Lithium (Li)	38
Manganese (Mn)	38
Molybdenum (Mo)	38
Nickel (Ni)	43
Lead (Pb)	43
Antimony (Sb)	47
Selenium (Se)	47
Tin (Sn)	47
Strontium (Sr)	47
Vanadium (V)	47
Zinc (Zn)	52

(continued)

TABLE OF CONTENTS
(concluded)

	Page
Lake Michigan	55
Regional Metal Concentrations	55
Trace Metal Trends	58
Silver (Ag)	58
Aluminum (Al)	62
Arsenic (As)	62
Barium (Ba)	69
Beryllium (Be)	69
Bismuth (Bi)	69
Cadmium (Cd)	69
Cobalt (Co)	75
Chromium (Cr)	75
Copper (Cu)	82
Iron (Fe)	89
Mercury (Hg)	89
Lithium (Li)	96
Manganese (Mn)	96
Molybdenum (Mo)	103
Nickel (Ni)	103
Lead (Pb)	110
Antimony (Sb)	110
Selenium (Se)	115
Tin (Sn)	115
Strontium (Sr)	115
Vanadium (V)	121
Zinc (Zn)	121
Discussion	128
Dissolved Metal Concentrations	128
Total Metal Concentrations	128
Estimated Fraction of Total Metal in Particulates	131
Water Quality Agreement Objectives and Observed Metal Concentrations	133
Potential Toxicity of Metal Mixtures	133
Summary	136
Literature Cited	139
Appendix	143

LIST OF FIGURES

Number		Page
1	Lake Erie trace metal water sampling stations occupied in 1981	3
2	Lake Michigan trace metal water sampling stations occupied in 1981	4

LIST OF TABLES

Number		Page
1	Percent metal recovery for concentration of lake waters by freeze drying prior to analysis	5
2	Mean limit of detection for analysis of 1981 Lakes Erie and Michigan water samples	7
3	Criterion of detection for analysis of 1981 Lakes Erie and Michigan water samples	9
4	Blank corrections applied to 1981 Lakes Erie and Michigan total and dissolved metal results	10
5	Performance of the Great Lakes Research Division trace metal laboratory in Interlaboratory Comparability Study No. 42 administered by the Data Quality Work Group of the International Joint Commission	12
6	Water Quality Agreement objectives for metal concentrations in Lakes Erie and Michigan waters	15
7	Dissolved metal concentrations in various basins of Lake Erie for 1981	16
8	Total metal concentrations in various basins of Lake Erie for 1981	18
9	Concentration of total Ag in Lake Erie waters collected from an unknown depth	20
10	Concentration of dissolved Ag in Lake Erie waters collected from depths less than 5 m	20
11	Concentration of total Ag in Lake Erie waters collected from depths less than 5 m	20
12	Concentration of total Ag in Lake Erie waters collected from an unknown depth	21
13	Concentration of total Al in Lake Erie waters collected from depths less than 5 m	21
14	Concentration of dissolved Al in Lake Erie waters collected from depths less than 5 m	21
15	Concentration of total As in Lake Erie waters collected from an unknown depth	22
16	Concentration of dissolved As in Lake Erie waters collected from depths less than 5 m	22
17	Concentration of total As in Lake Erie waters collected from depths less than 5 m	22
18	Concentration of dissolved Ba in Lake Erie waters collected from depths less than 5 m	24
19	Concentration of total Ba in Lake Erie waters collected from depths less than 5 m	24
20	Concentration of dissolved Be in Lake Erie waters collected from depths less than 5 m	24
21	Concentration of total Be in Lake Erie waters collected from depths less than 5 m	25
22	Concentration of dissolved Bi in Lake Erie waters collected from depths less than 5 m	25
23	Concentration of total Bi in Lake Erie waters collected from depths less than 5 m	26

(continued)

LIST OF TABLES
(continued)

Number		Page
24	Concentration of total Cd in Lake Erie waters collected from an unknown depth	26
25	Concentration of dissolved Cd in Lake Erie waters collected from depths less than 5 m	27
26	Concentration of total Cd in Lake Erie waters collected from depths less than 5 m	27
27	Concentration of total Co in Lake Erie waters collected from an unknown depth	29
28	Concentration of dissolved Co in Lake Erie waters collected from depths less than 5 m	29
29	Concentration of total Co in Lake Erie waters collected from depths less than 5 m	29
30	Concentration of total Cr in Lake Erie waters collected from an unknown depth	30
31	Concentration of dissolved Cr in Lake Erie waters collected from depths less than 5 m	30
32	Concentration of total Cr in Lake Erie waters collected from depths less than 5 m	31
33	Concentration of total Cu in Lake Erie waters collected from an unknown depth	31
34	Concentration of dissolved Cu in Lake Erie waters collected from depths less than 5 m	32
35	Concentration of total Cu in Lake Erie waters collected from depths less than 5 m	32
36	Concentration of dissolved Fe in Lake Erie waters collected from an unknown depth	34
37	Concentration of total Fe in Lake Erie waters collected from an unknown depth	34
38	Concentration of dissolved Fe in Lake Erie waters collected from depths less than 5 m	35
39	Concentration of total Fe in Lake Erie waters collected from depths less than 5 m	36
40	Concentration of total Hg in Lake Erie waters collected from an unknown depth	36
41	Concentration of dissolved Hg in Lake Erie waters collected from depths less than 5 m	37
42	Concentration of total Hg in Lake Erie waters collected from depths less than 5 m	37
43	Concentration of total Li in Lake Erie waters collected from depths less than 5 m	39
44	Concentration of dissolved Li in Lake Erie waters collected from depths less than 5 m	39

(continued)

LIST OF TABLES
(continued)

Number		Page
45	Concentration of total Mn in Lake Erie waters collected from an unknown depth	40
46	Concentration of dissolved Mn in Lake Erie waters collected from depths less than 5 m	41
47	Concentration of total Mn in Lake Erie waters collected from depths less than 5 m	41
48	Concentration of dissolved Mo in Lake Erie waters collected from depths less than 5 m	42
49	Concentration of total Mo in Lake Erie waters collected from depths less than 5 m	42
50	Concentration of total Ni in Lake Erie waters collected from an unknown depth	44
51	Concentration of dissolved Ni in Lake Erie waters collected from depths less than 5 m	44
52	Concentration of total Ni in Lake Erie waters collected from depths less than 5 m	45
53	Concentration of total Pb in Lake Erie waters collected from an unknown depth	45
54	Concentration of dissolved Pb in Lake Erie waters collected from depths less than 5 m	46
55	Concentration of total Pb in Lake Erie waters collected from depths less than 5 m	46
56	Concentration of dissolved Sb in Lake Erie waters collected from depths less than 5 m	48
57	Concentration of total Sb in Lake Erie waters collected from depths less than 5 m	48
58	Concentration of total Se in Lake Erie waters collected from an unknown depth	49
59	Concentration of dissolved Se in Lake Erie waters collected from depths less than 5 m	49
60	Concentration of total Se in Lake Erie waters collected from depths less than 5 m	49
61	Concentration of dissolved Sn in Lake Erie waters collected from depths less than 5 m	50
62	Concentration of total Sn in Lake Erie waters collected from depths less than 5 m	50
63	Concentration of dissolved Sr in Lake Erie waters collected from depths less than 5 m	50
64	Concentration of total Sr in Lake Erie waters collected from depths less than 5 m	51
65	Concentration of dissolved V in Lake Erie waters collected from depths less than 5 m	51

(continued)

LIST OF TABLES
(continued)

Number		Page
66	Concentration of total V in Lake Erie waters collected from depths less than 5 m	53
67	Concentration of total Zn in Lake Erie waters collected from an unknown depth	53
68	Concentration of dissolved Zn in Lake Erie waters collected from depths less than 5 m	54
69	Concentration of total Zn in Lake Erie waters collected from depths less than 5 m	54
70	Dissolved metal concentrations in waters from various regions of Lake Michigan for 1981	56
71	Total metal concentrations in waters from various regions of Lake Michigan for 1981	57
72	Concentration of dissolved Ag in Lake Michigan waters collected from an unknown depth	59
73	Concentration of total Ag in Lake Michigan waters collected from an unknown depth	60
74	Concentration of dissolved Ag in Lake Michigan waters collected from depths less than 5 m	61
75	Concentration of total Ag in Lake Michigan waters collected from depths less than 5 m	61
76	Concentration of dissolved Al in Lake Michigan waters collected from an unknown depth	63
77	Concentration of total Al in Lake Michigan waters collected from an unknown depth	63
78	Concentration of dissolved Al in Lake Michigan waters collected from depths less than 5 m	64
79	Concentration of total Al in Lake Michigan waters collected from depths less than 5 m	64
80	Concentration of dissolved As in Lake Michigan waters collected from an unknown depth	65
81	Concentration of total As in Lake Michigan waters collected from an unknown depth	66
82	Concentration of dissolved As in Lake Michigan waters collected from depths less than 5 m	67
83	Concentration of total As in Lake Michigan waters collected from depths less than 5 m	68
84	Concentration of dissolved Ba in Lake Michigan waters collected from an unknown depth	70
85	Concentration of total Ba in Lake Michigan waters collected from an unknown depth	70

(continued)

LIST OF TABLES
(continued)

Number		Page
86	Concentration of dissolved Ba in Lake Michigan waters collected from depths less than 5 m	71
87	Concentration of total Ba in Lake Michigan waters collected from depths less than 5 m	71
88	Concentration of dissolved Be in Lake Michigan waters collected from an unknown depth	72
89	Concentration of total Be in Lake Michigan waters collected from an unknown depth	72
90	Concentration of dissolved Be in Lake Michigan waters collected from depths less than 5 m	73
91	Concentration of total Be in Lake Michigan waters collected from depths less than 5 m	73
92	Concentration of dissolved Bi in Lake Michigan waters collected from depths less than 5 m	73
93	Concentration of total Bi in Lake Michigan waters collected from depths less than 5 m	74
94	Concentration of dissolved Cd in Lake Michigan waters collected from an unknown depth	74
95	Concentration of total Cd in Lake Michigan waters collected from an unknown depth	76
96	Concentration of dissolved Cd in Lake Michigan waters collected from depths less than 5 m	76
97	Concentration of total Cd in Lake Michigan waters collected from depths less than 5 m	77
98	Concentration of dissolved Co in Lake Michigan waters collected from an unknown depth	78
99	Concentration of total Co in Lake Michigan waters collected from an unknown depth	78
100	Concentration of dissolved Co in Lake Michigan waters collected from depths less than 5 m	79
101	Concentration of total Co in Lake Michigan waters collected from depths less than 5 m	79
102	Concentration of dissolved Cr in Lake Michigan waters collected from an unknown depth	80
103	Concentration of total Cr in Lake Michigan waters collected from an unknown depth	81
104	Concentration of dissolved Cr in Lake Michigan waters collected from depths less than 5 m	83
105	Concentration of total Cr in Lake Michigan waters collected from depths less than 5 m	84

(continued)

LIST OF TABLES
(continued)

Number		Page
106	Concentration of dissolved Cu in Lake Michigan waters collected from an unknown depth	85
107	Concentration of total Cu in Lake Michigan waters collected from an unknown depth	86
108	Concentration of dissolved Cu in Lake Michigan waters collected from depths less than 5 m	87
109	Concentration of total Cu in Lake Michigan waters collected from depths less than 5 m	88
110	Concentration of dissolved Fe in Lake Michigan waters collected from an unknown depth	90
111	Concentration of total Fe in Lake Michigan waters collected from an unknown depth	91
112	Concentration of dissolved Fe in Lake Michigan waters collected from depths less than 5 m	92
113	Concentration of total Fe in Lake Michigan waters collected from depths less than 5 m	93
114	Concentration of dissolved Hg in Lake Michigan waters collected from an unknown depth	94
115	Concentration of total Hg in Lake Michigan waters collected from an unknown depth	94
116	Concentration of dissolved Hg in Lake Michigan waters collected from depths less than 5 m	95
117	Concentration of total Hg in Lake Michigan waters collected from depths less than 5 m	97
118	Concentration of dissolved Li in Lake Michigan waters collected from an unknown depth	98
119	Concentration of total Li in Lake Michigan waters collected from an unknown depth	98
120	Concentration of dissolved Li in Lake Michigan waters collected from depths less than 5 m	98
121	Concentration of total Li in Lake Michigan waters collected from depths less than 5 m	99
122	Concentration of dissolved Mn in Lake Michigan waters collected from an unknown depth	99
123	Concentration of total Mn in Lake Michigan waters collected from an unknown depth	100
124	Concentration of dissolved Mn in Lake Michigan waters collected from depths less than 5 m	101
125	Concentration of total Mn in Lake Michigan waters collected from depths less than 5 m	102

(continued)

LIST OF TABLES
(continued)

Number		Page
126	Concentration of dissolved Mo in Lake Michigan waters collected from an unknown depth	104
127	Concentration of total Mo in Lake Michigan waters collected from an unknown depth	104
128	Concentration of dissolved Mo in Lake Michigan waters collected from depths less than 5 m	105
129	Concentration of total Mo in Lake Michigan waters collected from depths less than 5 m	105
130	Concentration of dissolved Ni in Lake Michigan waters collected from an unknown depth	106
131	Concentration of total Ni in Lake Michigan waters collected from an unknown depth	107
132	Concentration of dissolved Ni in Lake Michigan waters collected from depths less than 5 m	108
133	Concentration of total Ni in Lake Michigan waters collected from depths less than 5 m	109
134	Concentration of dissolved Pb in Lake Michigan waters collected from an unknown depth	111
135	Concentration of total Pb in Lake Michigan waters collected from an unknown depth	112
136	Concentration of dissolved Pb in Lake Michigan waters collected from depths less than 5 m	112
137	Concentration of total Pb in Lake Michigan waters collected from depths less than 5 m	113
138	Concentration of total Sb in Lake Michigan waters collected from an unknown depth	114
139	Concentration of dissolved Sb in Lake Michigan waters collected from depths less than 5 m	114
140	Concentration of total Sb in Lake Michigan waters collected from depths less than 5 m	114
141	Concentration of dissolved Se in Lake Michigan waters collected from an unknown depth	116
142	Concentration of total Se in Lake Michigan waters collected from an unknown depth	116
143	Concentration of dissolved Se in Lake Michigan waters collected from depths less than 5 m	117
144	Concentration of total Se in Lake Michigan waters collected from depths less than 5 m	117
145	Concentration of total Sn in Lake Michigan waters collected from an unknown depth	118

(continued)

LIST OF TABLES
(concluded)

Number		Page
146	Concentration of dissolved Sn in Lake Michigan waters collected from depths less than 5 m	118
147	Concentration of total Sn in Lake Michigan waters collected from depths less than 5 m	119
148	Concentration of dissolved Sr in Lake Michigan waters collected from an unknown depth	119
149	Concentration of dissolved Sr in Lake Michigan waters collected from depths less than 5 m	120
150	Concentration of total Sr in Lake Michigan waters collected from depths less than 5 m	120
151	Concentration of dissolved V in Lake Michigan waters collected from an unknown depth	122
152	Concentration of total V in Lake Michigan waters collected from an unknown depth	122
153	Concentration of dissolved V in Lake Michigan waters collected from depths less than 5 m	123
154	Concentration of total V in Lake Michigan waters collected from depths less than 5 m	123
155	Concentration of dissolved Zn in Lake Michigan waters collected from an unknown depth	124
156	Concentration of total Zn in Lake Michigan waters collected from an unknown depth	125
157	Concentration of dissolved Zn in Lake Michigan waters collected from depths less than 5 m	126
158	Concentration of total Zn in Lake Michigan waters collected from depths less than 5 m	127
159	Median dissolved metal concentrations in the waters of Lakes Erie, Michigan, and Huron	129
160	Median total metal concentrations in the waters of Lakes Erie, Michigan, and Huron	130
161	Estimated fraction of total metal concentration existing as particulate matter in the waters of Lakes Erie, Michigan, and Huron	132
162	Occurrences of Lakes Erie, Michigan, and Huron metal concentrations in water equalling or exceeding Water Quality Agreement objectives	134
163	Toxicity unit results for the waters of Lakes Erie, Michigan, and Huron	135
164	Summary of possible metal trends in the waters of Lakes Erie and Michigan	137

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INTRODUCTION

The quality of Great Lakes waters is of concern to scientists, managers, and the public. A great amount of interest centers on defining whether or not lake water quality is improving or deteriorating. To describe trends in lake water quality, an extensive, long-term data base of high quality is required.

For both Lakes Erie and Michigan, historical trace metal data are a mixture of total and dissolved metal concentrations. Total metal concentrations can vary considerably in a short period of time due to sediment resuspension. This is especially true for shallower lakes like Lake Erie. Thus total metal concentrations are expected to be highly variable. Filtered metal concentrations are less susceptible to perturbations caused by storm-induced sediment resuspension. Any trace metal study conducted for the purpose of assessing metal trends must include collection of both total and dissolved metal samples to be effective. In 1981, a study was conducted by the Great Lakes Research Division of The University of Michigan and supported by the Great Lakes National Program Office of the United States Environmental Protection Agency to address the above discussed needs.

METHODS

COLLECTION

The methods utilized for bottle preparation, filter preparation, filtration, and collection are described in Rossmann (1982). Trace metal-free filtration and sampling equipment were the same as those utilized for a similar study of Lake Huron waters (Rossmann 1982). All filtered samples were passed through Millipore Fluoropore® filters (FEP teflon) having a pore size of 0.5 μm.

Water samples for mercury analysis were stored in glass bottles and preserved with 5 mL of concentrated sulfuric acid plus 5 mL of 5% potassium dichromate. All other samples were stored in polyethylene bottles and preserved with 5 mL of concentrated Ultrex® nitric acid per liter of sample. The sampling stations in Lakes Erie and Michigan are portrayed in Figures 1 and 2, respectively. All samples were collected from a water depth of 1 m between October 13 and 29 of 1981 using the R/V Roger R. Simons. One station in each lake was replicated.

PREPARATION

For the majority of metals analyzed, the water samples required no preparation. Samples were concentrated nine- to eleven-fold by freeze drying prior to analysis for silver, beryllium, cobalt, antimony, selenium, tin, and vanadium. The methodology used was similar to that used by Rossmann (1982). The only change in methodology was that the final volume of each freeze-dried sample was determined by the weight of the bottle's contents.

For those metals requiring freeze drying, a percent recovery was estimated from freeze-dried standards. For all metals, the results were as expected (Table 1). Loss during freeze drying was unimportant. In fact, the possibility of sample contamination in the laboratory during sample manipulation was more of a problem.

ANALYSES

Excluding mercury, arsenic, calcium, magnesium, sodium, potassium, and strontium, all remaining metal analyses were done by flameless atomic absorption spectrophotometry using a graphite furnace (Perkin-Elmer 1977, Rossmann 1982). Generally, 100 µL of sample were injected for most metals to obtain the low detection limits necessary for those samples. Except for tin, quantitation was

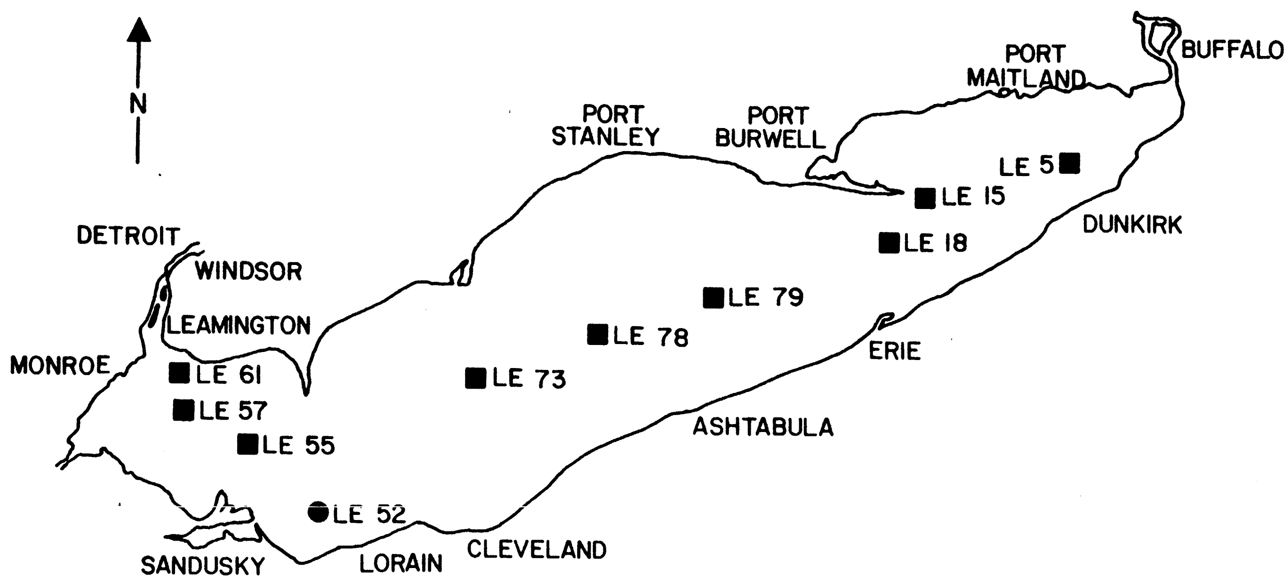

Figure 1. Lake Erie trace metal water sampling stations occupied in 1981.

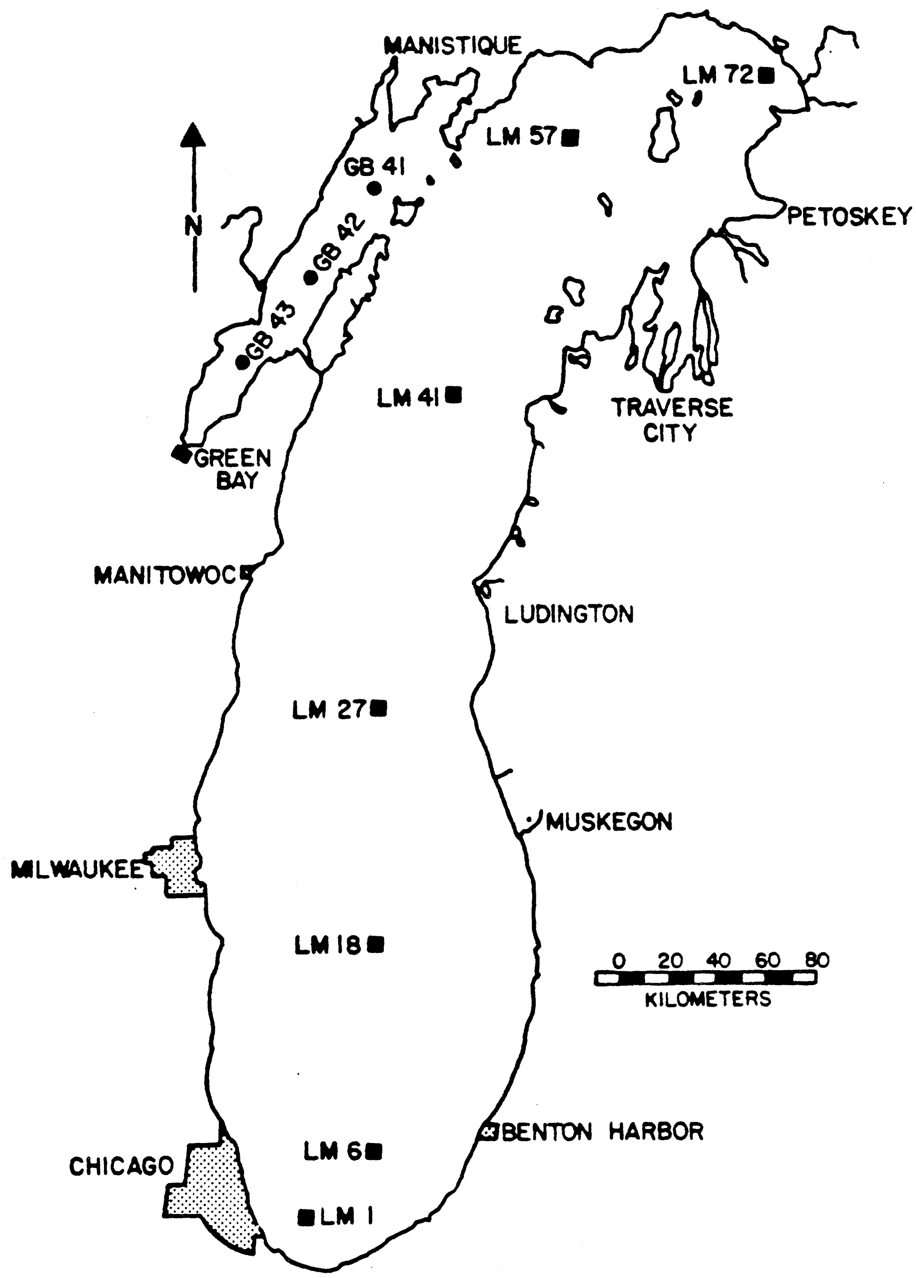

Figure 2. Lake Michigan trace metal water sampling stations occupied in 1981.

Table 1. Percent metal recovery for concentration of lake waters by freeze drying prior to analysis.

Element[1]	Measured Concentration[2]	Blank Concentration[2]	Blank Corrected Concentration[2]	True Concentration[2]	Percent Recovery
Ag	.0816 (.0114)	.00229 (.000440)	.0793	.0600	132
Ag	.0406 (.000588)	.00229 (.000440)	.0383	.0600	64
Be	.163 (.00384)	<.00454	.163	.100	163
Be	.127 (.00494)		.127	.100	127
Be	.166 (.00349)		.166	.100	166
Co	.0540 (.00137)	<.00236	.0540	.0500	108
Co	.0390 (.000811)		.0390	.0500	78
Co	.0388 (0.0)		.0388	.0500	78
Sb	.449 (.00224)	<.0121	.449	.300	150
Sb	.398 (.0132)		.398	.300	133
Sb	.471 (.00198)		.471	.300	157
Se	2.68 (.0726)	<.0298	2.68	2.0	134
Se	1.68 (.0506)		1.68	2.0	84
Se	2.65 (.231)		2.65	2.0	132
Sn	1.41 (.0464)	.0864 (.0342)	1.32	1.00	132
Sn	1.45 (.0377)		1.36	1.00	136
Sn	1.44 (.0788)		1.35	1.00	135
V	.428 (.00586)	<.0169	.428	.400	107
V	.383 (.00568)		.383	.400	96
V	.386 (.00288)		.386	.400	96

[1]Multiple entries for each element represent recoveries for different sets of recovery tests.
[2]μg/L; mean followed by standard deviation in parentheses.

with a standard curve; tin was analyzed by standard addition techniques. Calcium, magnesium, sodium, and potassium were analyzed by flame atomic absorption spectrophotometry using a standard curve for calibration. Strontium was also analyzed by flame atomic absorption spectrophotometry; however, the method of standard additions was used. Mercury analyses were done using the gold-amalgam technique (Perkin-Elmer 1981). This precluded the need to freeze-dry concentrate the mercury samples. Arsenic was analyzed using a Perkin-Elmer® Model MHS-20 hydride-mercury system. Quantitation was with a standard curve. All concentrations were calculated in the same manner as described by Rossmann (1982).

Limit of Detection

For each run consisting of standards, blanks, and samples, the limit of detection (minimum instrument response level) was determined by calculating the standard deviation of readings for multiple atomizations of air or distilled-deionized water. The standard deviations obtained from each of these blanks were then averaged, multiplied by 1.96 to provide for the 95% level of confidence (Hoel 1967), and divided by the slope of the regression line for the standards to convert to a concentration. Samples with concentrations below the limit of detection (W) are identified in each of the data tables which appear in the Appendix to this document. At the 95% level of confidence, the average limits of detection for all runs of each element are listed in Table 2.

Table 2. Mean limit of detection for analysis of 1981 Lakes Erie and Michigan water samples.

Element	Limit of Detection (μg/L)
Ag[1]	0.0020
Al	2.3
As	0.38
Ba	3.3
Be[1]	0.0039
Bi	0.28
Ca	71.
Cd	0.0053
Co[1]	0.0046
Cr	0.017
Cu	0.039
Fe	1.7
Hg	0.026
K	280.
Li	0.094
Mg	360.
Mn	0.13
Mo	0.084
Na	140.
Ni	0.087
Pb	0.033
Sb[1]	0.028
Se[1]	0.28
Sn[1]	0.021
Sr	4.0
V[1]	0.021
Zn	0.15

[1]Concentrated 10-fold by freeze drying.

Criterion of Detection

For all total and filtered water analyses, a criterion of detection was calculated for each metal. The criterion of detection was obtained by first discarding any obviously highly contaminated (non-representative) blanks, calculating the standard deviation of the remaining blanks, and then multiplying by 1.96 to provide for the 95% level of confidence (Hoel 1967). The criterion of detection for each metal is listed in Table 3. Samples having concentrations below the criterion of detection (T) are identified in each of the data tables which appear in the Appendix to this document.

Blanks

For each element analyzed, both total and filtered water sample blanks were analyzed. The total metal blank consisted of a bottle containing the appropriate preservative to which one liter of distilled-deionized water was added. The filtered metal blank consisted of a bottle containing the appropriate preservative into which one liter of distilled-deionized water was filtered prior to filtration of the lake water sample. Except for mercury, total and filtered metal blanks were collected at every station. For mercury, these blanks were collected at roughly one-half of the stations. If any median blank was appreciably large relative to measured sample concentrations, subsamples of the distilled-deionized water utilized to prepare the blanks were analyzed. After correction for the distilled-deionized water blanks, the total and dissolved blanks were used to correct the sample results. The blank corrections used are listed in Table 4. In general, dissolved blanks are

Table 3. Criterion of detection for analysis of 1981 Lakes Erie and Michigan water samples (μg/L).

Element	Total	Filtered
Ag	0.00091	0.0024
Al	0.95	1.1
As	0.019	0.0
Ba	5.6	4.7
Be	0.0032	.0032
Bi	0.26	0.29
Ca	0.0	0.0
Cd	0.0025	0.0079
Co	0.0045	0.0039
Cr	0.041	0.067
Cu	0.048	0.060
Fe	1.4	1.6
Hg	0.016	0.033
K	0.0	0.0
Li	0.0096	0.042
Mg	0.0	0.0
Mn	0.053	0.053
Mo	0.039	0.073
Na	0.0	0.0
Ni	0.044	0.098
Pb	0.11	0.069
Sb	0.042	0.038
Se	0.33	0.11
Sn	0.36	0.46
Sr	0.0	0.0
V	0.045	0.031
Zn	0.24	0.25

Table 4. Blank corrections applied to 1981 Lakes Erie and Michigan total and dissolved metal results (µg/L).

Element	Correction for Total	Correction for Dissolved Samples
Ag	0.0	0.0
Al	0.54	0.70
As	0.0	0.0
Ba	0.0	0.0
Be	0.0	0.0
Bi	0.0	0.0
Ca	0.0	0.0
Cd	0.0	0.0
Co	0.0	0.0
Cr	0.027	0.065
Cu	0.048	0.064
Fe	0.54	0.88
Hg	0.030	0.032
K	0.0	0.0
Li	0.0	0.0
Mg	0.0	0.0
Mn	0.0	0.0
Mo	0.0	0.0
Na	0.0	0.0
Ni	0.0	0.0
Pb	0.060	0.074
Sb	0.0	0.0
Se	0.0	0.0
Sn	0.0	0.0
Sr	0.0	0.0
V	0.039	0.027
Zn	0.0	0.0

greater than total blanks because of the increased handling of samples during the filtration process.

Inter-laboratory Comparison

In addition to our normal quality control procedures (Rossmann 1982), samples provided by the Data Quality Work Group of the International Joint Commission were analyzed. Selected at random, 7 of the possible 12 metals were analyzed, and samples exceeding the range of our standard curve were not repeated. The metals analyzed include chromium, copper, iron, manganese, nickel, lead, and zinc. In Table 5, the results of analyses at the Great Lakes Research Division are compared with the median concentration calculated from results obtained by all participating laboratories. In general, the two compare favorably. Only for iron in sample 3 and zinc in samples 1, 5, and 6 were GLRD results flagged for being low. In no instances were GLRD results flagged for being high. The reported zinc median may be high due to sample contamination. It is one of the most easily contaminating metals.

Manipulation of STORET Data

The STORET data bases for both Lake Erie and Lake Michigan are extremely large. Because of this and the expense involved to manipulate the data, the total and dissolved metals concentrations were sorted by year and depth of collection. This sorting did not permit the removal of nearshore stations, including rivers and intakes. Not only was it impractical to remove the nearshore stations, but it also was impractical to subset the data by month of collection. For each year, those data representative of the epilimnion

Table 5. Performance of the Great Lakes Research Division (GLRD) trace metal laboratory in Interlaboratory Comparability Study No. 42 (total metals in water) administered by the Data Quality Work Group of the International Joint Commission (concentrations in μg/L).

	1		2		3		4		5		6		7		8		9		10	
Metal	GLRD	Median	GLRD	Median	GLRD	Median	GLRD	Median	GLRD	Median	GLRD	Median	GLRD	Median	GLRD	Median	GLRD	Median	GLRD	Median
Cr	2.0	1.9	3.1	2.0	2.5	3.0	>10.	45.	3.9	4.0	—	6.8	>10.	26.	>10.	52.	—	13.	>10.	81.
Cu	4.2	4.3	1.4	2.0	9.5	8.9	>10.	60.	4.3	4.5	5.8	5.8	>10.	13.	8.6	9.0	>10.	19.	>10.	88.
Fe	2.5	5.5	16.	19.	5.4bb	14.	>50.	130.	>50.	140.	33.	34.	>100.	150.	>100.	200.	>100.	120.	>100.	180.
Mn	5.3	5.0	1.8	3.0	1.5	2.0	>30.	63.	>30.	48.	5.0	5.0	>30.	50.	27.	25.	12.	11.	>30.	110.
Ni	0.56	1.2	3.3	3.2	2.0	2.0	98.	98.	6.4	6.0	2.1	2.0	6.1	5.8	3.6	4.0	3.2	3.0	>100.	560.
Pb	3.9	4.0	0.64	1.0	0.31T	0.66	>30.	87.	1.3	3.0	12.	10.	>30.	49.	>30.	91.	>30.	40.	>30.	330.
Zn	18.b	21.	16.	16.	9.0	9.0	>30.	71.	17.b	20.	24.b	29.	>30.	60.	>30.	110.	>30.	82.	>30.	130.

T = Below the criterion of detection.
b or bb = Sample flagged for being below median concentration.

(<5 m water depth) were summarized. In addition, many stations had no water depth associated with them. Because of their possible historical significance, they were also summarized. These data probably included intakes. For each lake and metal, the compiled data for each year were statistically analyzed to obtain concentration range, mean concentration, standard deviation of the mean, and median concentration.

The purpose of this treatment of the data was not only to summarize the STORET trace metal data for the waters of each lake, but also to examine the quality of the data. Throughout the text which follows, statements concerning the quality of each data set are presented whenever there is a question concerning the representativeness of the data. It was not the author's intent to correct or discard data but simply to provide one expert opinion. The reader is left to form his or her own conclusions about the data presented.

RESULTS

In the sections which follow, results for each lake are presented for: 1) geographic metal differences and 2) metal trends. All results and discussions which follow are based upon median concentrations, not mean concentrations. The complete metals data set is contained in the tables of the Appendix. To assess metal trends, historical data have been summarized by year. The majority of the historical data are contained within STORET. For Lake Michigan, a large data base derived from power plant siting and impact studies has been assembled. All historical data and results dependent upon these data must be used with caution. At the time of their generation, they may or may not have represented high quality data for the state-of-the-art methodology used.

To estimate the potential toxicity of metal mixtures the toxic unit concept as recommended and described in an Aquatic Ecosystems Objectives Committee report to the Great Lakes Science Advisory Board of the International Joint Commission (1980) will be used. The recommended approach is to sum the ratios of each metal concentration (M_i) to its respective objective concentration (O_i). The sum should not exceed 1.0. Water Quality Agreement objectives are summarized in Table 6. Except for mercury, all objectives are on the basis of total metal concentrations.

LAKE ERIE

Regional Metal Concentrations

For the purpose of assessing regional variations in metal concentrations, Lake Erie was divided into three geographic basins: eastern, central, and western. Dissolved metal concentrations for these three basins are summarized in Table 7. All results are observational and not based upon statistical testing of the data set. Most metals exhibited a regional pattern and may be placed into one of the following categories: no regional variation, increasing concentration from west to east, or lowest concentration in the central basin. Potassium, magnesium, lead, and vanadium had no regional variation. Silver, barium, beryllium, calcium, cobalt, lithium, molybdenum, sodium, selenium, and strontium progressively increased from west to east. Aluminum, bismuth, cadmium, chromium, copper, iron, mercury, manganese, nickel, and zinc concentrations were lowest in the central basin. Tin increased from east to west, and antimony and arsenic were highest in the western and central basins.

Table 6. Water Quality Agreement objectives for metal concentrations in Lakes Erie and Michigan waters (μg/L).[1]

Metal	IJC Objective
Ag	0.1
As	50.
Cd	0.2
Cr	50.
Cu	5.0
Fe	300.
Pb	5.0
Hg	0.20[2]
Ni	25.
Se	1.0[3]
Zn	30.

[1] International Joint Commission (1978)
[2] filtered sample
[3] recommended objective

Table 7. Dissolved metal concentrations (μg/L) in various basins of Lake Erie for 1981.

	East (n=3)			Central (n=4)			West (n=3)		
Element	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median
Ag	0.031	0.0061	0.030	0.031	0.015	0.020	0.014	0.010	0.0080
Al	22.	13.	22.	12.	9.1	8.5	47.	19.	56.
As	0.28	0.16	0.28	0.50	0.24	0.46	0.35	0.13	0.42
Ba	51.	0.74	51.	49.	1.9	48.	42.	1.2	42.
Be	0.018	0.0015	0.017	0.018	0.0061	0.017	0.015	0.0025	0.014
Bi	1.2	0.55	1.1	0.75	0.53	0.45	0.62	0.28	0.69
Ca[1]	35.	1.6	35.	34.	2.0	33.	28.	1.2	29.
Cd	0.068	0.027	0.065	0.061	0.022	0.044	0.076	0.036	0.067
Co	0.10	0.0055	0.10	0.072	0.018	0.069	0.046	0.044	0.045
Cr	0.39	0.12	0.45	0.27	0.17	0.17	0.33	0.20	0.27
Cu	1.5	0.22	1.4	0.46	0.17	0.38	0.82	0.34	0.89
Fe	13.	1.0	13.	8.5	5.6	5.3	32.	11.	36.
Hg	0.074	0.029	0.088	0.065	0.032	0.049	0.070	0.037	0.076
K[1]	1.2	0.023	1.1	1.2	0.052	1.1	1.1	0.091	1.2
Li	1.8	0.14	1.8	1.7	0.20	1.6	1.4	0.44	1.2
Mg[1]	9.9	0.40	9.7	10.	0.34	10.	9.7	0.24	9.7
Mn	0.39	0.20	0.45	0.37	0.080	0.32	0.42	0.18	0.48
Mo	1.7	0.096	1.7	1.5	0.21	1.4	1.2	0.27	1.3
Na[1]	9.1	0.14	9.1	8.5	0.22	8.4	5.6	0.62	5.8
Ni	1.3	0.18	1.3	1.2	0.14	1.1	1.6	0.40	1.7
Pb	0.18	0.038	0.16	0.23	0.14	0.15	0.23	0.24	0.17
Sb	0.074	0.0082	0.069	0.33	0.13	0.28	0.24	0.083	0.21
Se	2.9	0.95	3.2	2.9	0.89	2.5	1.8	0.85	1.5
Sn	0.38	0.071	0.40	1.5	1.3	0.57	2.7	1.4	2.1
Sr	150.	8.5	150.	150.	20.	140.	110.	20.	100.
V	0.31	0.14	0.33	0.32	0.067	0.31	0.29	0.16	0.37
Zn	1.0	0.38	1.1	1.1	0.90	0.49	2.6	1.7	3.2

[1]mg/L

Total metal concentrations in the eastern, central, and western basins are summarized in Table 8. Only median magnesium concentrations had no distinct regional variation. Bismuth, calcium, molybdenum, and sodium concentrations increased from west to east. Except for bismuth, this was also true for the dissolved metal concentrations. Aluminum, barium, mercury, manganese, nickel, lead, tin, vanadium, and zinc increased from east to west. This increase and the occurrence of highest concentrations of aluminum, barium, beryllium, cadmium, cobalt, chromium, copper, iron, mercury, potassium, lithium, manganese, nickel, lead, tin, vanadium, and zinc illustrate results expected when the western basin of Lake Erie is sampled during and immediately after a storm event. Resuspended sediments contributed significant amounts of metals, as particulates, to the measured total metal concentrations.

Trace Metal Trends

In order to assess metal trends and to make comments on historical data, STORET and other data were summarized. All data not identified to specific source are compiled from STORET. In many instances, nearshore data are included in the STORET data utilized. It was impractical to sift through the data station by station to remove nearshore stations. It was also impractical to subset the data based upon the time of year collected. For each metal, two major summaries were compiled for both total and dissolved concentrations. These are concentrations for which no collection depth was reported and epilimnion concentrations (depths less than 5 m). The first summary is presented for information only. Trends were assessed using only epilimnion samples. Because of the questionable quality of much of the historical data, all trends calculated using regression analysis of median concentrations are

Table 8. Total metal concentrations (μg/L) in various basins of Lake Erie for 1981.

	East (n=3)			Central (n=4)			West (n=3)		
Element	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median
Ag	0.038	0.0021	0.039	0.025	0.0097	0.019	0.035	0.013	0.033
Al	57.	19.	52.	120.	80.	97.	4200.	1800.	5100.
As	0.30	0.020	0.30	0.57	0.14	0.54	0.61	0.28	0.52
Ba	49.	1.1	49.	51.	3.0	52.	55.	4.3	57.
Be	0.039	0.038	0.022	0.022	0.0072	0.021	0.16	0.088	0.20
Bi	1.4	0.28	1.5	0.68	0.38	0.45	0.37	0.19	0.28
Ca[1]	35.	0.57	35.	35.	1.2	34.	31.	0.87	31.
Cd	0.058	0.020	0.052	0.051	0.014	0.044	0.20	0.10	0.14
Co	0.086	0.024	0.096	0.077	0.023	0.068	0.59	0.45	0.84
Cr	0.38	0.035	0.39	0.29	0.094	0.30	3.6	0.68	3.6
Cu	2.1	0.52	2.1	1.0	0.38	0.84	3.0	1.7	2.3
Fe	42.	4.6	42.	76.	45.	37.	1400.	220.	1400.
Hg	0.075	0.062	0.048	0.082	0.057	0.063	0.066	0.0052	0.065
K[1]	1.2	0.030	1.2	1.2	0.015	1.2	1.6	0.14	1.6
Li	1.9	0.079	1.9	1.9	0.21	1.7	3.2	0.14	3.3
Mg[1]	10.	0.39	10.	11.	0.050	11.	10.	0.30	10.
Mn	2.4	0.96	2.3	10.	3.0	8.9	44.	11.	48.
Mo	2.1	0.13	2.1	1.5	0.48	1.2	1.2	0.29	1.2
Na[1]	9.3	0.11	9.3	8.6	0.18	8.6	5.8	0.63	6.2
Ni	1.0	0.32	0.85	0.99	0.13	1.0	2.9	1.5	2.3
Pb	0.21	0.039	0.20	0.26	0.096	0.21	2.4	0.66	2.4
Sb	0.062	0.041	0.071	0.31	0.11	0.34	0.056	0.025	0.047
Se	2.8	1.2	2.2	2.6	0.72	2.5	0.85	0.97	0.63
Sn	0.18	0.031	0.18	2.8	2.3	1.4	2.3	1.2	1.9
Sr	150.	10.	140.	150.	9.8	150.	130.	24.	120.
V	0.30	0.068	0.32	0.48	0.11	0.42	3.2	1.3	3.7
Zn	0.95	0.27	0.96	1.2	0.69	1.1	20.	3.7	18.

[1] mg/L

apparent trends and not necessarily real trends. They are provided as information to the reader and should not be used as a given fact.

Silver (Ag)

Silver data for samples collected at an unknown depth are available as total metal concentrations for only 1975 (Table 9). For epilimnion samples, dissolved metal data are available for two years (Table 10), and total metal data are available for three years (Table 11). The 1979 dissolved metal data are below the limit of detection. The large difference between 1981 total metal data and the 1978 and 1979 data, indicating severe sample contamination, invalidates the older data. No metal trends can be assessed.

Aluminum (Al)

Total aluminum concentrations in samples collected from an unknown depth are available for two years (Table 12). Total concentrations in samples collected from the epilimnion are summarized for four years (Table 13), and dissolved concentrations are summarized for three years (Table 14). No trend is evident. Concentrations were lowest in 1979.

Arsenic (As)

Historical total arsenic data for samples collected from an unknown depth are available for 1975 and 1980 (Table 15). No historical epilimnetic dissolved arsenic data exist. The 1981 data are summarized in Table 16. Total arsenic in the epilimnion data are available for four years (Table 17). Considering the years 1978, 1979, and 1981, total arsenic in the epilimnion appears to be decreasing at a rate of 0.31 µg/L/yr (correlation coefficient (r)=0.99).

Table 9. Concentration (μg/L) of total Ag in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1975	2	0.20	0.30	0.25	0.071	--

Table 10. Concentration (μg/L) of dissolved Ag in Lake Erie waters collected from a depth less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1979	271	5.0	5.0	5.0	0.0	5.0
1981[1]	11	0.0077	0.048	0.026	0.013	0.026

[1]This study.

Table 11. Concentration (μg/L) of total Ag in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	79	0.60	190.	4.1	22.	1.0
1979	641	-1.5	120.	2.9	6.4	1.0
1981[1]	11	0.019	0.050	0.033	0.010	0.035

[1]This study.

Table 12. Concentration (μg/L) of total Al in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1976	1	500.	500.	--	--	--
1980	6	25.	98.	37.	30.	25.

Table 13. Concentration (μg/L) of total Al in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1975	1	40.	40.	--	--	--
1978	795	0.0	18000.	560.	960.	250.
1979	643	-60.	5000.	100.	340.	33.
1981[1]	11	20.	5300.	1300.	2000.	180.

[1]This study.

Table 14. Concentration (μg/L) of dissolved Al in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	708	0.0	8000.	150.	410.	100.
1979	564	-110.	550.	12.	30.	10.
1981[1]	11	3.2	60.	24.	19.	22.

[1]This study.

Table 15. Concentration (μg/L) of total As in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1975	2	1.0	1.0	1.0	0.0	--
1980	6	10.	10.	10.	0.0	10.

Table 16. Concentration (μg/L) of dissolved As in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.12	0.80	0.38	0.19	0.42

[1]This study.

Table 17. Concentration (μg/L) of total As in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1975	1	0.40	0.40	--	--	--
1978	198	0.0	14.	1.8	2.0	1.4
1979	650	0.0	8.0	1.1	1.0	0.95
1981[1]	11	0.28	0.92	0.49	0.20	0.43

[1]This study.

Barium (Ba)

No historical dissolved barium data were found for epilimnetic waters. The 1981 data are summarized in Table 18. Total barium data for these waters exists for three years (Table 19). An uncertain increasing total barium concentration trend may exist. If so, the rate of increase is 13 μg/L/yr (r=0.94). The historical total barium data are suspiciously low.

Beryllium (Be)

No historical dissolved beryllium data were found for epilimnetic water. The 1981 data are summarized in Table 20. For total beryllium, epilimnion historical data are available for three years (Table 21). Though the historical data are suspiciously high, a tentative significant decreasing trend was calculated for total beryllium. The rate is 0.060 μg/L/yr (r=0.94).

Bismuth (Bi)

No historical data were found for either dissolved or total bismuth. The 1981 concentrations are summarized in Tables 22 and 23.

Cadmium (Cd)

Total cadmium data for unknown depths exist for five years (Table 24). For the epilimnion, dissolved cadmium data exist for seven years (Table 25). The 1963, 1964, and 1970 medians appear to be at the limit of detection. The remaining historical data are suspiciously high. No trend can be determined for these data. Historical epilimnion total cadmium data are available for five years (Table 26). The 1967 (n=69) and 1975 medians appear to be at the limit of detection. The 1978 and 1979 data are suspiciously high. For the years 1975, 1978, 1979, and 1981, no trend exists.

Table 18. Concentration (μg/L) of dissolved Ba in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	41.	52.	47.	3.8	48.

[1]This study.

Table 19. Concentration (μg/L) of total Ba in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	79	1.0	29.	16.	4.1	16.
1979	74	11.	23.	16.	2.0	16.
1981[1]	11	47.	58.	52.	3.4	52.

[1]This study.

Table 20. Concentration (μg/L) of dissolved Be in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	10	0.011	0.026	0.017	0.0039	0.017

[1]This study.

Table 21. Concentration (μg/L) of total Be in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	79	0.0	7.0	0.28	0.77	0.20
1979	74	0.0	50.	2.9	11.	0.20
1981[1]	11	0.013	0.22	0.074	0.076	0.032

[1]This study.

Table 22. Concentration (μg/L) of dissolved Bi in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.31	1.9	0.84	0.48	0.69

[1]This study.

Table 23. Concentration (μg/L) of total Bi in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.24	1.6	0.75	0.50	0.58

[1]This study.

Table 24. Concentration (μg/L) of total Cd in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1973	2	10.	16.	13.	4.2	--
1974	27	1.0	1.0	1.0	0.0	1.0
1975	2	0.20	0.20	0.20	0.0	--
1976	1	3.0	3.0	--	--	--
1980	6	2.0	2.0	2.0	0.0	2.0

Table 25. Concentration (μg/L) of dissolved Cd in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1963	33	10.	10.	10.	0.0	10.
1964	16	10.	10.	10.	0.0	10.
1970	9	1.0	2.0	1.1	0.33	1.0
1971	112	0.10	2.3	0.68	0.53	0.50
1978	708	0.0	15.	2.5	2.4	1.3
1979	567	-1.5	6.6	0.68	0.67	1.0
1981[1]	11	0.041	0.12	0.071	0.027	0.067

[1]This study.

Table 26. Concentration (μg/L) of total Cd in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1967	3	0.0010	1.0	0.67	0.58	1.0
1967[1]	69	0.0	1.0	.043	.20	0.0
1975	44	0.0	0.20	0.0045	0.030	0.0
1978	768	0.0	349.	4.4	15.	3.0
1979	644	-0.20	50.	1.0	2.1	1.0
1981[2]	11	0.039	0.32	0.098	0.081	0.072

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

Cobalt (Co)

Historical total cobalt concentrations at unknown depths exist for 1974 and 1975 (Table 27). All data are at the limit of detection. For the epilimnion, dissolved and total cobalt data are available for three and four years, respectively (Tables 28 and 29). Excluding the 1971 dissolved cobalt data, all historical data medians are at the limit of detection. The 1971 dissolved cobalt data are suspiciously high. No trend was determined for these data.

Chromium (Cr)

Total chromium data for samples from unknown depths exist for five years (Table 30). All data appear to be at the limit of detection. Dissolved chromium data for the epilimnion exist for five years (Table 31). The 1970 median is at the limit of detection. Compared with 1971 and 1981, the 1978 and 1979 maximum concentrations are suspiciously high. No trend was found for dissolved chromium. Total chromium historical data for the epilimnion are available for seven years (Table 32). All pre-1978 median concentrations are at the limit of detection. For the three remaining years, a tentative decreasing total chromium trend exists. The rate of change is 0.60 μg/L/yr ($r=0.89$).

Copper (Cu)

Total copper data for unknown depths are available for five years (Table 33). Except for 1975, all median concentrations are probably at the limit of detection. For the epilimnion, dissolved copper data are available for seven years (Table 34). The 1963 median is at the limit of detection. The 1964 and 1968 medians are suspiciously high. No significant trend was found. Total epilimnetic copper data are available for six years (Table 35). The 1967 ($n=60$)

Table 27. Concentration (μg/L) of total Co in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1974	20	10.	10.	10.	0.0	10.
1975	30	10.	10.	10.	0.0	10.

Table 28. Concentration (μg/L) of dissolved Co in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	19	1.0	2.0	1.1	0.23	1.0
1971	89	0.10	4.8	0.76	0.70	0.50
1981[1]	11	0.0023	0.11	0.075	0.032	0.089

[1]This study.

Table 29. Concentration (μg/L) of total Co in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1967[1]	67	0.0	0.0	0.0	0.0	0.0
1978	79	1.0	22.	1.5	2.5	1.0
1979	74	1.0	2.0	1.0	0.16	1.0
1981[2]	11	0.050	0.85	0.23	0.31	0.096

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

Table 30. Concentration (μg/L) of total Cr in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1973	2	20.	20.	20.	0.0	--
1974	27	5.0	20.	7.2	4.4	5.0
1975	2	5.0	5.0	5.0	0.0	--
1976	1	20.	20.	--	--	--
1980	6	10.	10.	10.	0.0	10.

Table 31. Concentration (μg/L) of dissolved Cr in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	5	1.0	3.0	1.4	0.89	1.0
1971	108	0.10	3.8	0.50	0.49	0.40
1978	717	0.0	750.	8.6	35.	1.2
1979	567	-0.20	70.	3.5	5.9	1.4
1981[1]	11	0.14	0.55	0.33	0.15	0.27

[1]This study.

Table 32. Concentration (μg/L) of total Cr in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1963	33	10.	10.	10.	0.0	10.
1964	16	10.	10.	10.	0.0	10.
1967[1]	69	0.0	0.0	0.0	0.0	0.0
1973	5	20.	20.	20.	0.0	20.
1978	793	0.0	2300.	12.	82.	2.0
1979	643	-2.3	400.	4.8	17.	2.3
1981[2]	11	0.16	4.3	1.3	1.5	0.39

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

Table 33. Concentration (μg/L) of total Cu in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1973	2	20.	20.	20.	0.0	--
1974	47	5.0	20.	7.4	4.1	5.0
1975	32	3.0	22.	7.9	3.8	8.0
1976	1	20.	20.	--	--	--
1980	6	10.	15.	11.	2.0	10.

Table 34. Concentration (µg/L) of dissolved Cu in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1963	33	10.	30.	11.	3.5	10.
1964	16	9.0	10.	9.9	0.25	10.
1970	111	1.0	22.	2.7	2.6	2.0
1971	102	0.50	11.	3.1	2.2	2.0
1978	702	0.0	1800.	67.	180.	10.
1979	567	-0.50	66.	6.2	7.4	3.7
1981[1]	11	0.33	1.7	0.85	0.48	0.70

[1]This study.

Table 35. Concentration (µg/L) of total Cu in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1967	60	0.0030	18.	1.6	4.0	0.018
1967[1]	69	0.0	37.	16.	8.0	16.
1973	5	30.	40.	32.	4.5	30.
1975	44	0.0	80.	7.3	19.	0.0
1978	793	0.0	2200.	18.	99.	5.0
1979	642	0.60	160.	10.	16.	5.0
1981[2]	11	0.61	5.0	1.9	1.2	1.8

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

median and minimum concentrations are suspiciously low. The data were probably input to STORET as mg/L instead of as μg/L. The 1973 median is at the limit of detection which is relatively high compared with the other medians. The 1975 median is also at the limit of detection, and is suspiciously low. The 1967 median is suspiciously high. The 1978 and 1979 medians are suspiciously high. No trend was found.

Iron (Fe)

For unknown depths, dissolved iron data are available for 1928 and 1951 (Table 36), and total iron data are available for thirteen years (Table 37). For the epilimnion, dissolved iron data are available for nine years (Table 38). The 1976 median is suspiciously high; that for 1979 is suspiciously low. No significant trend was found.

Epilimnion total iron data are available for ten years (Table 39). The 1963 and 1965 medians are at the limit of detection. For the remaining years, no trend was found.

Mercury (Hg)

For an unknown depth, total mercury data exist for five years (Table 40). The 1976 and 1980 data are suspiciously high. Epilimnion dissolved mercury data exist for three years (Table 41). The 1970 data are suspiciously high and the median is at the limit of detection. A meaningful trend cannot be derived from the two remaining years of data. For total mercury in the epilimnion, data exist for six years (Table 42). Total mercury appears to be decreasing at a rate of .012 μg/L/yr (r=0.87).

Table 36. Concentration (μg/L) of dissolved Fe in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1928	1	380.	380.	--	--	--
1951	3	960.	66000.	23000.	37000.	1300.

Table 37. Concentration (μg/L) of total Fe in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1957	2	150.	780.	460.	450.	--
1965	6	110.	420.	200.	120.	130.
1966	6	160.	3000.	870.	1100.	180.
1968	82	80.	1900.	500.	380.	370.
1969	15	220.	920.	560.	220.	520.
1970	18	320.	3500.	890.	840.	540.
1971	1	46000.	46000.	--	--	--
1972	31	0.0	61000.	2300.	11000.	160.
1973	8	20.	58000.	25000.	21000.	30000.
1974	71	80.	3400.	700.	710.	400.
1975	33	40.	670.	220.	150.	180.
1976	3	150.	620.	340.	250.	240.
1980	6	50.	110.	59.	23.	50.

Table 38. Concentration (μg/L) of dissolved Fe in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969	10	20.	140.	56.	44.	40.
1970	111	1.0	30.	4.1	4.3	2.0
1971	134	1.0	42.	5.7	4.6	4.8
1972	29	1.5	23.	6.3	5.5	4.0
1973	21	3.0	31.	11.	7.6	8.0
1976	74	20.	6800.	270.	780.	140.
1978	718	0.0	3200.	30.	160.	8.0
1979	567	-75.	200.	13.	30.	0.025
1981[1]	11	4.1	41.	16.	12.	13.

[1]This study.

Table 39. Concentration (μg/L) of total Fe in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1963	33	63.	63.	63.	0.0	63.
1964	6	30.	520.	180.	180.	120.
1965	2	100.	100.	100.	0.0	--
1967	60	5.0	1300.	200.	230.	100.
1967[1]	69	8.0	4700.	435.	828.	133.
1968	13	53.	3400.	650.	910.	340.
1972	29	7.0	380.	34.	69.	16.
1973	22	9.0	1200.	130.	250.	53.
1978	500	0.0	9100.	600.	950.	270.
1979	374	24.	5300.	450.	790.	160.
1981[2]	11	37.	1500.	470.	610.	100.

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

Table 40. Concentration (μg/L) of total Hg in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	1	0.50	0.50	--	--	--
1974	48	0.20	20.	0.84	2.9	0.20
1975	30	0.10	2.2	0.46	0.58	0.15
1976	1	2.0	2.0	--	--	--
1980	6	1.0	1.2	1.0	0.082	1.0

Table 41. Concentration (μg/L) of dissolved Hg in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	3	1.0	3.0	1.7	1.1	1.0
1971	124	0.050	1.1	0.30	0.26	0.20
1981[1]	11	-0.00080	0.080	0.034	0.029	0.024

[1]This study.

Table 42. Concentration (μg/L) of total Hg in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970-1[1]	170	0.0	0.40	0.17	0.11	
1975	1	0.050	0.050	—	—	—
1978	618	0.0	130.	0.37	5.4	0.037
1979	596	-0.10	1.0	0.081	0.11	0.060
1981[2]	11	0.00030	0.14	0.042	0.044	0.033

[1]Chau and Saitoh (1973).
[2]This study.

Lithium (Li)

For the epilimnion, total lithium data exist for 1967 and 1981 (Table 43). The 1967 data were input into STORET as mg/L instead of as μg/L. Dissolved lithium historical data for the epilimnion exist for three years (Table 44). No trend was found for dissolved lithium.

Manganese (Mn)

Total manganese data for an unknown depth are available for ten years (Table 45). The data of 1957, 1965, and 1973 are at the limit of detection. The 1970 and 1976 data are suspiciously high. For the epilimnion, dissolved manganese data are available for seven years (Table 46). The 1970 median is at the limit of detection, and the 1978 median is suspiciously high. No dissolved manganese trend was found. Total manganese data exist for six years (Table 47). The 1967 (n=62) median is low. It probably was incorrectly entered into STORET as mg/L instead of as μg/L. Excluding that data set, no total manganese trend was found.

Molybdenum (Mo)

Epilimnion dissolved molybdenum data are available for three years (Table 48). The 1970 median is at the limit of detection. In this case, a tentative trend can still be calculated. Dissolved molybdenum is increasing at the rate of 0.043 μg/L/yr (r=0.99). Total molybdenum epilimnion data are available for three years (Table 49). Both the 1978 and 1979 medians are at the limit of detection; hence, no trend could be determined.

Table 43. Concentration (μg/L) of total Li in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1967	62	0.0010	12.	0.71	2.0	0.003
1981[1]	11	1.71	3.4	2.3	0.66	2.0

[1]This study.

Table 44. Concentration (μg/L) of dissolved Li in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	112	1.0	8.0	3.1	2.0	2.0
1971	122	0.80	9.4	1.7	0.87	1.6
1981[1]	11	1.1	2.0	1.6	0.29	1.7

[1]This study.

Table 45. Concentration (μg/L) of total Mn in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1957	2	0.0	0.0	0.0	0.0	--
1965	6	0.0	10.	3.3	5.2	0.0
1966	6	0.0	10.	8.3	4.1	10.
1970	4	100.	270.	200.	84.	160.
1972	24	10.	2900.	190.	600.	30.
1973	3	20.	20.	20.	0.0	20.
1974	28	0.0	80.	29.	26.	31.
1975	32	3.0	25.	11.	5.9	9.0
1976	1	4400.	4400.	--	--	--
1980	6	20.	20.	20.	0.0	20.

Table 46. Concentration (μg/L) of dissolved Mn in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	26	1.0	8.0	1.5	1.5	1.0
1971	119	0.10	19.	0.98	2.0	0.50
1972	25	0.60	20.	3.8	4.1	2.7
1973	20	0.90	15.	3.1	3.9	1.3
1978	720	0.37	180.	10.	17.	5.0
1979	561	-9.0	230.	6.7	17.	2.0
1981[1]	11	0.13	0.56	0.37	0.15	0.37

[1]This study.

Table 47. Concentration (μg/L) of total Mn in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1967	62	0.0020	290.	7.6	38.	0.024
1967[1]	69	2.0	560.	52.	88.	18.
1972	29	1.0	75.	9.5	15.	5.5
1973	21	1.0	15.	6.8	4.3	5.9
1978	787	0.0	260.	18.	26.	8.0
1979	643	-41.	284.	21.	35.	5.0
1981[2]	11	1.5	52.	20.	20.	12.

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

Table 48. Concentration (μg/L) of dissolved Mo in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	112	1.0	2.0	1.2	0.42	1.0
1971	128	0.30	7.0	1.2	0.60	1.1
1981[1]	11	0.94	1.8	1.5	0.25	1.5

[1]This study.

Table 49. Concentration (μg/L) of total Mo in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	79	2.0	29.	2.7	3.3	2.0
1979	74	2.0	4.0	2.3	0.53	2.0
1981[1]	11	0.86	2.3	1.6	0.50	1.4

[1]This study.

Nickel (Ni)

Total nickel data for samples collected from an unknown depth are available for five years (Table 50). The 1973 and 1980 data appear to be at the limit of detection and are suspiciously high. For the epilimnion, dissolved nickel data are available for seven years (Table 51). The 1963 and 1964 medians are at the limit of detection. For the remaining years, no significant trend was found. For total nickel in the epilimnion, data are available for seven years (Table 52). The 1967 (n=59) data were probably accidentally entered into STORET as mg/L instead of µg/L. The 1973 median appears to be the limit of detection, and the 1976 median is suspiciously high. For the remaining years, no significant trend was found.

Lead (Pb)

Total lead data for samples collected from unknown depths are available for five years (Table 53). The 1974 and 1980 medians appear to be at the limit of detection. Dissolved lead data for the epilimnion are available for seven years (Table 54). The 1963, 1964, and 1970 medians are at the limit of detection. The 1978 median appears to be unrealistically high. No trend could be determined. Epilimnion total lead data are available for six years (Table 55). The 1967 (n=60) data were apparently improperly input to STORET as mg/L rather than µg/L. The medians for 1973, 1978, and 1979 are suspiciously high. No trend could be determined.

Table 50. Concentration (μg/L) of total Ni in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1973	2	30.	30.	30.	0.0	--
1974	34	1.0	24.	12.	4.8	15.
1975	30	5.0	30.	9.5	6.7	7.0
1976	1	80.	80.	--	--	--
1980	6	20.	20.	20.	0.0	20.

Table 51. Concentration (μg/L) of dissolved Ni in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1963	33	10.	10.	10.	0.0	10.
1964	16	10.	15.	10.	1.2	10.
1970	112	1.0	12.	2.2	1.3	2.0
1971	107	0.50	8.0	1.7	0.98	1.5
1978	719	0.0	420.	9.6	24.	4.5
1979	567	0.0	85.	9.0	8.3	6.1
1981[1]	11	1.0	1.8	1.4	0.28	1.3

[1]This study.

Table 52. Concentration (μg/L) of total Ni in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1967	59	0.0010	20.	0.78	2.8	0.0030
1967[1]	66	1.0	56.	5.9	8.9	3.0
1973	5	40.	40.	40.	0.0	40.
1975	43	0.0	40.	14.	10.	20.
1976	7	150.	1300.	500.	420.	350.
1978	784	0.0	1100.	24.	52.	10.
1979	642	-5.7	670.	21.	52.	7.5
1981[2]	11	0.80	4.6	1.6	1.1	1.1

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

Table 53. Concentration (μg/L) of total Pb in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1973	2	50.	84.	67.	24.	--
1974	47	5.0	46.	9.3	7.3	5.0
1975	32	2.0	30.	14.	6.2	13.
1976	1	50.	50.	--	--	--
1980	6	10.	10.	10.	0.0	10.

Table 54. Concentration (μg/L) of dissolved Pb in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1963	33	20.	31.	21.	2.7	20.
1964	16	20.	20.	20.	0.0	20.
1970	104	1.0	15.	1.4	1.4	1.0
1971	101	0.10	5.0	1.5	0.97	1.2
1978	717	0.0	840.	23.	58.	25.
1979	567	-14.	130.	6.6	16.	5.0
1981[1]	11	0.020	0.50	0.22	0.14	0.17

[1]This study.

Table 55. Concentration (μg/L) of total Pb in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1967	60	.0010	10.	0.92	2.2	0.0040
1967[1]	68	0.0	12.	4.4	2.4	4.0
1973	5	7.0	7.0	7.0	0.0	7.0
1975	44	0.0	2.0	0.045	0.30	0.0
1978	792	0.0	400.	17.	29.	9.0
1979	644	-1.9	67.	6.1	4.8	5.0
1981[2]	11	0.15	3.0	0.91	1.0	0.34

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

Antimony (Sb)

No historical antimony data were found. The 1981 data are summarized in Tables 56 and 57.

Selenium (Se)

For unknown depths, total selenium data exist for 1974 and 1975 (Table 58). Both data sets appear to be at the limit of detection. No historical epilimnion dissolved data were found. The 1981 data are summarized in Table 59. For the epilimnion, total selenium data are available for four years (Table 60). The 1975 data consist of one observation. For the remaining years, no trend was found.

Tin (Sn)

For the epilimnion, no historical dissolved tin data were found. Those of 1981 are summarized in Table 61. Epilimnion total tin data are available for three years (Table 62). No total tin concentration trend was found.

Strontium (Sr)

For the epilimnion, dissolved strontium data exist for 1971 and 1981 (Table 63), and total strontium data exist for 1967 and 1981 (Table 64). The 1967 (n=62) data appear to have been entered into STORET as mg/L rather than as µg/L. Sparcity of data prevented calculating a meaningful trend.

Vanadium (V)

Epilimnion dissolved vanadium data are available for three years (Table 65). Though the apparent trend for dissolved vanadium is one of a decrease at a rate of 3.1 µg/L/yr (r=0.98), the 1978 and 1979 data are

Table 56. Concentration (μg/L) of dissolved Sb in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.069	0.45	0.21	0.14	0.17

[1]This study.

Table 57. Concentration (μg/L) of total Sb in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.0	0.40	0.15	0.15	0.085

[1]This study.

Table 58. Concentration (μg/L) of total Se in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1974	14	5.0	5.0	5.0	0.0	5.0
1975	2	5.0	5.0	5.0	0.0	--

Table 59. Concentration (μg/L) of dissolved Se in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	1.1	4.0	2.5	0.90	2.5

[1]This study.

Table 60. Concentration (μg/L) of total Se in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1975	1	0.10	0.10	--	--	--
1978	703	0.0	26.	1.4	1.6	1.5
1979	651	0.0	3.0	0.92	0.95	0.43
1981[1]	11	0.0	4.2	2.0	1.2	2.1

[1]This study.

Table 61. Concentration (μg/L) of dissolved Sn in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.28	4.2	1.5	1.3	1.1

[1]This study.

Table 62. Concentration (μg/L) of total Sn in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	106	2.0	20.	7.7	6.0	6.0
1979	74	6.0	20.	14.	6.9	20.
1981[1]	11	0.16	5.9	2.0	1.8	1.4

[1]This study.

Table 63. Concentration (μg/L) of dissolved Sr in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1971	124	100.	210.	160.	18.	170.
1981[1]	11	100.	180.	140.	22.	140.

[1]This study.

Table 64. Concentration (µg/L) of total Sr in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1967	62	0.12	460.	34.	83.	0.16
1967[1]	69	120.	1500.	230.	220.	160.
1981[2]	11	110.	160.	140.	17.	140.

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

Table 65. Concentration (µg/L) of dissolved V in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	719	0.0	800.	32.	80.	10.
1979	343	-15.	86.	5.7	5.6	5.0
1981[1]	11	0.10	0.43	0.31	0.10	0.35

[1]This study.

suspiciously high. For the epilimnion, total vanadium data are available for five years (Table 66). The 1973 data are at the limit of detection, and the 1978 and 1979 data are suspiciously high as they are for the dissolved data. The remaining years' medians cannot be used to calculate a meaningful trend.

Zinc (Zn)

Total zinc data for an unknown depth are available for five years (Table 67). The 1980 data appear to be at the limit of detection. Epilimnion dissolved zinc data exist for seven years (Table 68). Except for 1979, all pre-1981 medians are suspiciously high. No significant trend was found. For the epilimnion, total zinc data exist for six years (Table 69). The 1967 (n=54) data appear to have been entered into STORET as mg/L instead of μg/L. The 1973 data are suspiciously high. The 1975 median is at the limit of detection. The 1978 and 1979 medians are also suspiciously high. No trend was found.

Thus, dissolved metal concentrations of Mo are increasing, and those of V are decreasing. Total metal concentrations for As, Be, Cr, and Hg appear to be decreasing. Concentrations of total Ba appear to be increasing. Any decreasing trends may be an artifact of improved methodology and detection limits.

Table 66. Concentration (μg/L) of total V in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1971	35	0.10	0.80	0.29	0.19	0.20
1973	5	50.	50.	50.	0.0	50.
1978	797	0.0	3800.	56.	250.	10.
1979	399	-8.9	55.	5.5	6.6	5.0
1981[1]	11	0.23	4.1	1.2	1.4	0.42

[1]This study.

Table 67. Concentration (μg/L) of total Zn in Lake Erie waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1973	2	50.	60.	55.	7.1	--
1974	34	5.0	140.	20.	25.	13.
1975	32	5.0	195.	23.	35.	14.
1976	1	90.	90.	--	--	--
1980	6	50.	50.	50.	0.0	50.

Table 68. Concentration (μg/L) of dissolved Zn in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1963	33	9.0	52.	21.	7.7	20.
1964	16	17.	82.	27.	17.	20.
1970	113	1.0	90.	8.8	11.	6.0
1971	94	1.0	75.	8.4	8.6	7.2
1978	659	0.0	25000.	140.	1200.	11.
1979	566	-8.4	450.	13.	34.	3.5
1981[1]	11	0.32	4.0	1.6	1.2	1.3

[1]This study.

Table 69. Concentration (μg/L) of total Zn in Lake Erie waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1967	54	0.0020	59.	4.0	11.	0.010
1967[1]	68	0.0	80.	12.	15.	8.0
1973	5	300.	2100.	660.	800.	300.
1975	44	0.0	90.	9.9	22.	0.0
1978	743	0.0	510.	45.	70.	19.
1979	645	1.0	820.	37.	65.	24.
1981[2]	11	0.55	24.	6.5	8.8	1.2

[1]CCIW data reported in Weiler and Chawla (1968) and Chawla and Chau (1969).
[2]This study.

LAKE MICHIGAN

Regional Metal Concentrations

To investigate regional metal variations in lake water, Lake Michigan was divided into four geographic regions: Green Bay, southern, central, and northern. Dissolved metal concentrations for the four regions are summarized in Table 70. In general, southern Lake Michigan and Green Bay had the highest metal concentrations, and central Lake Michigan had the lowest concentrations. Green Bay had relatively high aluminum, arsenic, cobalt, chromium, iron, manganese, nickel, tin, and vanadium concentrations. Southern Lake Michigan had relatively high aluminum, mercury, nickel, lead, antimony, selenium, and tin concentrations. Central Lake Michigan had relatively low concentrations of aluminum, beryllium, bismuth, cadmium, cobalt, chromium, iron, nickel, and tin. Metals which were similar in concentration for all regions included silver, barium, calcium, potassium, magnesium, molybdenum, sodium, and strontium.

Total metal concentrations for each of the selected regions are summarized in Table 71. Green Bay had relatively high concentrations of aluminum, arsenic, beryllium, cadmium, cobalt, iron, mercury, manganese, and vanadium. It also had the lowest chromium, lead, antimony, selenium, and tin concentrations. Central Lake Michigan was notable for its low silver, aluminum, cobalt, iron, nickel, and lead concentrations. Total metals which displayed little areal variability included barium, calcium, potassium, lithium, magnesium, molybdenum, sodium, strontium, and zinc.

Table 70. Dissolved metal concentrations (μg/L) in waters from various regions of Lake Michigan for 1981.

	Green Bay (n=3)			Southern (n=3)			Central (n=3)			Northern (n=2)		
Element	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median
Ag	0.052	0.016	0.047	0.054	0.013	0.050	0.055	0.0037	0.054	0.050	0.0011	--
Al	11.	9.4	8.1	6.0	4.2	8.2	30.	51.	0.79	5.8	2.9	--
As	0.95	0.19	0.84	0.66	0.32	0.50	0.53	0.11	0.52	0.92	0.19	--
Ba	47.	2.7	47.	48.	3.6	46.	44.	3.9	43.	48.	3.4	--
Be	0.012	0.0056	0.0097	0.012	0.0033	0.011	0.0080	0.0015	0.0079	0.012	0.0047	--
Bi	0.96	0.30	0.83	1.0	0.39	0.79	0.72	0.077	0.69	1.1	0.099	--
Ca[1]	35.	1.2	35.	33.	0.058	33.	35.	2.9	34.	31.	0.0	--
Cd	0.046	0.0036	0.045	0.045	0.0059	0.046	0.033	0.0071	0.031	0.12	0.096	--
Co	0.079	0.016	0.083	0.050	0.0081	0.049	0.036	0.00076	0.035	0.045	0.0065	--
Cr	0.79	0.53	0.71	0.54	0.15	0.55	0.53	0.23	0.54	0.76	0.25	--
Cu	0.45	0.18	0.36	0.60	0.52	0.32	0.32	0.055	0.34	0.26	0.096	--
Fe	4.3	1.8	4.2	1.9	1.3	1.8	9.8	16.	0.68	2.7	2.2	--
Hg	0.071	0.025	0.066	0.054	0.013	0.080	0.11	0.043	0.082	0.049	0.025	--
K[1]	1.1	0.095	1.1	1.0	0.017	1.0	1.0	0.012	1.0	0.95	0.082	--
Li	2.0	0.64	2.3	2.0	0.55	1.7	7.6	9.0	2.6	2.0	0.45	--
Mg[1]	15.	0.31	15.	15.	0.12	15.	14.	0.40	14.	14.	0.64	--
Mn	0.65	0.41	0.87	0.11	0.013	0.11	0.19	0.050	0.17	0.092	0.081	--
Mo	1.1	0.13	1.0	1.3	0.13	1.3	1.3	0.13	1.3	1.3	0.064	--
Na[1]	5.3	0.44	5.2	5.0	0.065	5.0	5.0	0.0	5.0	4.7	0.37	--
Ni	0.59	0.23	0.70	0.80	0.17	0.74	0.51	0.062	0.52	0.63	0.011	--
Pb	0.071	0.043	0.082	0.24	0.028	0.22	0.17	0.029	0.18	0.076	0.033	--
Sb	0.10	0.10	0.064	0.26	0.024	0.27	0.30	0.026	0.31	0.19	0.0078	--
Se	2.3	0.99	1.8	3.2	0.39	3.1	2.9	0.49	3.1	1.8	0.16	--
Sn	4.6	4.9	1.9	3.9	4.5	1.5	0.35	0.24	0.29	0.85	0.94	--
Sr	110.	2.0	110.	120.	1.7	110.	110.	9.9	110.	98.	16.	--
V	0.60	0.32	0.77	0.36	0.16	0.32	0.39	0.16	0.45	0.28	0.067	--
Zn	0.54	0.41	0.35	0.51	0.13	0.48	0.44	0.11	0.41	1.3	1.0	--

[1]mg/L

Table 71. Total metal concentrations (μg/L) in waters from various regions of Lake Michigan for 1981.

	Green Bay (n=3)			Southern (n=3)			Central (n=3)			Northern (n=2)		
Element	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median	$\overline{X}$	σ	Median
Ag	0.059	0.0016	0.059	0.080	0.038	0.074	0.052	0.0047	0.050	0.050	0.0046	—
Al	71.	17.	63.	22.	17.	16.	14.	17.	8.3	45.	6.9	—
As	1.1	0.20	0.99	0.60	0.11	0.65	0.58	0.094	0.54	0.96	0.078	—
Ba	46.	2.8	46.	45.	3.5	43.	42.	2.4	41.	48.	0.42	—
Be	0.052	0.027	0.065	0.019	0.0025	0.019	0.011	0.0038	0.0096	0.013	0.00014	—
Bi	0.54	0.17	0.61	0.99	0.36	0.80	0.67	0.13	0.67	1.2	0.49	—
Ca[1]	35.	0.62	35.	33.	0.058	33.	34.	0.51	34.	32.	0.49	—
Cd	0.060	0.024	0.048	0.031	0.012	0.029	0.038	0.0098	0.038	0.040	0.0083	—
Co	0.095	0.0080	0.091	0.075	0.020	0.080	0.051	0.011	0.057	0.056	0.012	—
Cr	0.60	0.064	0.58	0.73	0.081	0.76	0.70	0.031	0.71	0.68	0.21	—
Cu	0.34	0.20	0.31	0.39	0.19	0.35	0.57	0.17	0.59	0.31	0.16	—
Fe	74.	20.	76.	16.	10.	15.	8.0	6.9	4.5	34.	20.	—
Hg	0.087	0.041	0.099	0.091	0.041	0.075	0.072	0.034	0.073	0.080	0.010	—
K[1]	1.1	0.093	1.1	1.0	0.017	1.1	1.1	0.026	1.1	0.95	0.082	—
Li	1.9	0.54	1.9	2.0	0.47	2.0	2.2	0.26	2.2	2.2	0.47	—
Mg[1]	15.	0.47	15.	15.	0.12	15.	14.	0.23	14.	14.	0.78	—
Mn	32.	21.	31.	0.30	0.074	0.27	0.43	0.13	0.49	1.4	0.78	—
Mo	0.91	0.26	0.76	1.0	0.20	0.99	1.3	0.50	1.0	1.2	0.11	—
Na[1]	5.3	0.44	5.3	5.1	0.098	5.0	5.0	0.12	5.0	4.8	0.33	—
Ni	0.67	0.18	0.59	0.68	0.12	0.68	0.50	0.082	0.46	0.74	0.075	—
Pb	0.22	0.056	0.24	0.34	0.053	0.36	0.18	0.058	0.17	0.33	0.21	—
Sb	0.17	0.15	0.11	0.27	0.025	0.27	0.29	0.033	0.30	0.16	0.038	—
Se	1.1	0.38	0.90	3.7	0.65	3.4	2.9	0.18	3.0	2.3	0.41	—
Sn	3.5	3.1	1.8	1.9	1.7	2.3	2.4	1.4	2.6	7.2	0.057	—
Sr	110.	5.1	120.	120.	4.0	120.	120.	3.5	120.	110.	6.4	—
V	0.89	0.28	0.81	0.35	0.11	0.32	0.50	0.16	0.56	0.36	0.14	—
Zn	0.62	0.060	0.59	0.59	0.13	0.56	0.52	0.20	0.43	0.80	0.38	—

[1]mg/L

Trace Metal Trends

Two major data sources of trace metal concentrations in Lake Michigan water are available: STORET and numerous power plant siting and impact studies. Many of the STORET data have no depth of collection associated with the reported concentrations. Because of this, dissolved and total metal concentrations are summarized both for unknown depths and for the epilimnion (depths less than 5 m). The data for unknown depths are presented for the reader's information. All trends are based on epilimnion data. The 1977 STORET data are discussed in detail with respect to historical trends by Rockwell *et al*. (1980).

Silver (Ag)

For samples collected from an unknown depth, dissolved silver data are available for thirteen years (Table 72). The 1966, 1968, 1971, 1973, 1975, 1976, and 1980 data are at the limit of detection. Total silver data are available for nine years (Table 73). The 1971, 1974, 1976, 1977, 1978, and 1979 data appear to be at the limit of detection. For epilimnion samples, dissolved silver data are available for three years (Table 74). Based on these years, dissolved silver appears to be decreasing at a rate of 0.0206 µg/L/yr (r=0.99); however, the trend is only tentative because of the sparcity of data and the distribution of data between the three years reported. Epilimnetic total silver data are available for five years (Table 75). The 1980 data are suspiciously high, and the medians for 1972, 1974, 1977, and 1981 (n=166) appear to be at the limit of detection. No trend was found.

Table 72. Concentration (μg/L) of dissolved Ag in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	0.30	0.30	0.30	--	--
1963	1	0.40	0.40	0.40	--	--
1964	2	0.80	1.6	1.2	0.56	--
1965	2	0.80	0.90	0.85	0.071	--
1966	3	0.90	0.90	0.90	0.0	0.90
1967	1	0.80	0.80	0.80	--	--
1968	3	0.80	0.80	0.80	0.0	0.80
1971	3	0.0	0.0	0.0	0.0	0.0
1972	9	1.0	5.0	4.1	1.8	5.0
1973	15	5.0	5.0	5.0	0.0	5.0
1974	19	1.0	4.0	1.7	0.80	2.0
1975	18	1.0	1.0	1.0	0.0	1.0
1976	6	1.0	1.0	1.0	0.0	1.0
1980	1	0.	0.	0.	--	--

Table 73. Concentration (μg/L) of total Ag in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1971	12	40.	40.	40.	0.0	40.
1974	2	25.	25.	25.	0.0	--
1975	19	0.020	25.	2.7	7.8	0.20
1976	19	1.0	1.0	1.0	0.0	1.0
1977	26	1.0	1.0	1.0	0.0	1.0
1978	29	1.0	61.	3.2	11.	1.0
1979	23	1.0	3.0	1.3	0.65	1.0
1980	1	2.0	2.0	2.0	--	--
1981	5	0.50	5.0	2.9	2.0	2.3

Table 74. Concentration (μg/L) of dissolved Ag in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	31	0.059	1.2	0.36	0.27	0.31
1970[1]	23	0.21	0.33	0.26	0.039	0.26
1981[2]	11	0.039	0.069	0.053	0.0096	0.050

[1]Copeland and Ayers (1972).
[2]This study.

Table 75. Concentration (μg/L) of total Ag in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	0.10	2.2	0.23	0.42	0.10
1974	42	0.10	10.	0.58	2.1	0.10
1977[2]	104	<3.	7.	<3.	—	—
1980	121	0.10	10.	1.1	0.82	1.0
1981	166	0.10	0.10	0.10	0.0	0.10
1981[3]	11	0.046	0.12	0.061	0.021	0.057

[1]Industrial Bio-Test Laboratories, Inc. (1975).
[2]Rockwell *et al*. (1980).
[3]This study.

Aluminum (Al)

For unknown depths, dissolved aluminum data are available for three years (Table 76), and total metal data are available for ten years (Table 77). The 1977, 1978, and 1981 data are suspiciously high. For the epilimnion, dissolved aluminum data are available for three years (Table 78). Dissolved aluminum appears to be decreasing at the rate of 0.818 μg/L/y ($r=0.96$); however, the year groupings utilized provide a poor representation for the 12-year period. Total aluminum data for the epilimnion exist for nine years (Table 79). All years for which medians exceed 100 μg/L (1972, 1973, 1974, 1975, and 1976) are suspiciously high or at the limit of detection. No significant trend was found.

Arsenic (As)

Dissolved arsenic data for samples from unknown depths are available for sixteen years (Table 80). The data of 1966, 1968, 1972, and 1973 are suspiciously high. For 1967, 1970, 1971, 1974, 1975, and 1976, the medians appear to be at the limit of detection. The 1979 data appear to have been entered into STORET as mg/L instead of as μg/L. Total metal data are available for sixteen years (Table 81). The 1967 and 1969 data are suspiciously high. The 1966, 1970, 1971, 1972, 1973, 1975, 1976, 1980, and 1981 medians are at the limit of detection. As for the dissolved arsenic, total metal data for 1979 appear to be entered improperly into STORET. Epilimnion dissolved arsenic data are available for four years (Table 82). No significant trend was found. Total arsenic data are available for eight years (Table 83). The 1972, 1973, 1974, 1976, 1977, 1980, and 1981 ($n=167$) medians appear to be at the limit of detection. No trend could be determined for these data.

Table 76. Concentration (μg/L) of dissolved Al in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1975	1	80.	80.	80.	--	--
1977	1	80.	80.	80.	--	--
1980	1	40.	40.	40.	--	--

Table 77. Concentration (μg/L) of total Al in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1963	1	7.0	7.0	7.0	--	--
1964	2	4.0	71.	38.	47.	--
1965	2	17.	20.	18.	2.1	--
1966	3	18.	28.	21.	5.8	18.
1967	1	16.	16.	16.	--	--
1968	3	16.	18.	17.	1.1	16.
1970	2	0.	100.	50.	71.	--
1977	1	2400.	2400.	2400.	--	--
1978	3	50.	5800.	2100.	3200.	560.
1981	2	100.	100.	100.	0.0	--

Table 78. Concentration (μg/L) of dissolved Al in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	31	3.8	140.	30.	30.	19.
1970[1]	23	7.5	150.	23.	30.	15.
1981[2]	11	0.72	89.	14.	26.	7.8

[1]Copeland and Ayers (1972).
[2]This study.

Table 79. Concentration (μg/L) of total Al in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	79	10.	90.	48.	17.	50.
1971	140	10.	240.	61.	48.	50.
1972	154	10.	150.	66.	39.	60.
1972[1]	105	100.	500.	150.	95.	100.
1973[2]	8	100.	500.	190.	150.	100.
1973[3]	6	100.	700.	200.	240.	100.
1974	42	10.	4300.	140.	660.	20.
1974[2,4]	44	100.	800.	260.	190.	200.
1974[5]	12	50.	400.	140.	110.	80.
1975[5]	12	10.	160.	78.	54.	50.
1975[4,6]	36	100.	800.	220.	190.	100.
1976[6]	30.	100.	1000.	230.	230.	100.
1976[5]	12	10.	650.	120.	180.	50.
1977[5]	6	20.	100.	50.	28.	40.
1981[7]	11	1.7	90.	37.	27.	40.

[1]Briars (1973).
[2]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[3]Katnik and Redmond (1974).
[4]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[5]Ellis (1977).
[6]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[7]This study.

Table 80. Concentration (μg/L) of dissolved As in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	14.	14.	14.	—	—
1963	1	15.	15.	15.	—	—
1964	2	20.	33.	26.	9.2	—
1965	2	30.	50.	40.	14.	—
1966	3	45.	50.	47.	2.6	46.
1967	11	0.	50.	4.5	15.	0.0
1968	3	40.	40.	40.	0.0	40.
1970	6	0.	10.	3.3	5.2	0.0
1971	6	0.	10.	3.7	5.0	0.0
1972	16	1.0	5.0	4.0	1.8	5.0
1973	15	1.0	5.0	3.6	1.8	5.0
1974	44	0.	12.	0.89	2.1	0.0
1975	18	1.0	2.0	1.1	0.32	1.0
1976	6	1.0	1.0	1.0	0.0	1.0
1979	9	0.0010	0.0020	0.0011	0.00033	0.001
1980	1	3.0	3.0	3.0	—	—

Table 81. Concentration (μg/L) of total As in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1966	5	0.	0.	0.	0.0	0.0
1967	3	0.	92.	37.	48.	20.
1968	13	0.	110.	32.	42.	3.0
1969	10	0.	110.	40.	36.	23.
1970	41	0.	94.	11.	27.	0.0
1971	261	0.	20.	1.1	4.3	0.0
1972	502	0.	40.	0.49	1.9	0.0
1973	249	0.	28.	0.47	2.5	0.0
1974	480	0.	12.	0.90	1.2	1.0
1975	178	0.	15.	0.57	1.8	0.0
1976	503	0.	5.	0.46	0.65	0.0
1977	31	0.	5.0	0.79	1.1	0.50
1978	47	0.20	200.	6.9	29.	2.0
1979	29	0.0010	6.4	0.60	1.5	0.0010
1980	24	1.0	2.0	1.3	0.48	1.0
1981	23	1.0	10.0	2.2	2.6	1.0

Table 82. Concentration (μg/L) of dissolved As in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	31	0.17	2.1	1.0	0.50	0.90
1970[1]	23	0.59	2.6	1.0	0.48	0.95
1970	79	10.	90.	48.	17.	8.5
1974	3	0.30	0.60	0.47	0.15	0.50
1981[2]	11	0.42	1.2	0.75	0.26	0.79

[1]Copeland and Ayers (1972).
[2]This study.

Table 83. Concentration (μg/L) of total As in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	1.0	2.0	1.2	0.33	1.0
1973[2]	6	1.0	1.0	1.0	0.0	1.0
1973[3]	8	50.	50.	50.	0.0	50.
1973[4]	48	1.0	4.0	1.4	0.64	1.0
1974[5]	30	1.0	2.0	1.0	0.18	1.0
1974[1]	49	0.80	10.	2.9	3.9	0.80
1974[2]	48	1.0	4.0	1.2	0.64	1.0
1975	1	1.0	1.0	1.0	--	--
1976[6]	18	1.0	2.0	1.1	0.24	1.0
1977[7]	11	<2.0	<2.0	<2.0	--	--
1980	121	1.0	2.0	1.0	0.091	1.0
1981	167	1.0	10.	1.0	0.70	1.0
1981[8]	11	0.48	1.3	0.79	0.26	0.69
1982	1	10.	10.	10.	--	--

[1]Katnik and Redmond (1974).
[2]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[3]Wiersma (1974).
[4]Gara and Hawley (1974).
[5]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[6]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[7]Rockwell *et al.* (1980).
[8]This study.

Barium (Ba)

Data for dissolved barium in water from an unknown depth are available for eleven years (Table 84). The 1974 median is at the limit of detection. The 1975 median is suspiciously low. Total barium concentrations are available for eleven years (Table 85). Except for 1978, all medians are either at the limit of detection or are suspiciously high. Epilimnetic dissolved barium data are available for five years (Table 86). No significant trend was found. Total barium concentrations in the epilimnion are available for five years (Table 87). The median for 1972 is at the limit of detection and that for 1974 is suspiciously high. No significant trend was identified.

Beryllium (Be)

For samples from unknown depths, dissolved beryllium data are available for seven years (Table 88); total metal data are available for three years (Table 89). Except for dissolved beryllium in 1964 and total metal in 1978, all data are at or near the limit of detection. No epilimnetic data for dissolved beryllium were found. The 1981 data are summarized in Table 90. Total beryllium data for the epilimnion are available for five years (Table 91). The 1972, 1974, 1975, and 1977 data are at the limit of detection. No trend was found.

Bismuth (Bi)

No historical data were found for either dissolved or total bismuth. The 1981 concentrations are summarized in Tables 92 and 93.

Cadmium (Cd)

Dissolved metal data reported for samples from unknown sample depths are available for seventeen years (Table 94). All medians are at the limit of

Table 84. Concentration (µg/L) of dissolved Ba in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	17.	17.	17.	--	--
1963	1	10.	10.	10.	--	--
1964	2	16.	17.	16.	0.71	--
1965	2	15.	20.	18.	3.5	--
1966	3	18.	26.	22.	4.0	21.
1967	1	22.	22.	22.	--	--
1968	3	15.	20.	18.	2.6	19.
1974	25	0.	100.	12.	33.	0.0
1975	17	10.	25.	13.	5.0	10.
1976	6	20.	60.	31.	15.	25.
1980	1	30.	30.	30.	--	--

Table 85. Concentration (µg/L) of total Ba in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	15	0.	0.	0.	0.0	0.0
1971	12	500.	500.	500.	0.0	500.
1972	302	0.	200.	0.99	12.8	0.0
1973	249	0.	100.	0.80	8.9	0.0
1974	175	0.	500.	11.	61.	0.0
1975	155	0.	700.	21.	97.	0.0
1976	192	0.	800.	23.	90.	0.0
1977	31	0.	600.	32.	110.	5.0
1978	14	5.0	780.	86.	200.	26.
1979	9	1.0	320.	120.	110.	72.
1981	2	170.	950.	560.	550.	--

Table 86. Concentration (μg/L) of dissolved Ba in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	31	6.1	85.	35.	15.	36.
1970[1]	23	7.5	110.	38.	24.	30.
1974[2]	52	15.	77.	35.	13.	35.
1975[2]	36	14.	120.	53.	20.	58.
1981[3]	11	41.	52.	47.	3.3	46.

[1]Copeland and Ayers (1972).
[2]Industrial Bio-Test Laboratories, Inc. (1975).
[3]This study.

Table 87. Concentration (μg/L) of total Ba in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	100.	100.	100.	0.0	100.
1974	2	100.	200.	150.	71.	—
1977[2]	102	8.	40.	12.	4.2	—
1980	121	10.	43.	26.	7.5	29.
1981	166	17.	36.	26.	3.2	26.
1981[3]	11	41.	49.	45.	3.1	45.

[1]Briars (1973).
[2]Rockwell *et al*. (1980).
[3]This study.

Table 88. Concentration (μg/L) of dissolved Be in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	0.030	0.030	0.030	--	--
1963	1	0.040	0.040	0.040	--	--
1964	2	0.040	0.070	0.055	0.021	--
1965	2	0.040	0.040	0.040	0.0	--
1966	3	0.050	0.050	0.050	0.0	0.050
1967	1	0.040	0.040	0.040	--	--
1968	3	0.080	0.080	0.080	0.0	0.080

Table 89. Concentration (μg/L) of total Be in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1974	18	5.0	5.0	5.0	0.0	5.0
1975	17	1.0	1.0	1.0	0.0	1.0
1978	3	0.10	1.0	0.70	0.52	1.0

Table 90. Concentration (μg/L) of dissolved Be in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.0066	0.018	0.011	0.0038	0.0096

[1]This study.

Table 91. Concentration (μg/L) of total Be in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	5.0	5.0	5.0	0.0	5.0
1974	40	0.50	0.50	0.50	0.0	0.50
1975	1	1.0	1.0	1.0	—	—
1977[2]	102	<2.0	<2.0	<2.0	—	—
1981[3]	11	0.0081	0.070	0.025	0.022	0.016

[1]Briars (1973).
[2]Rockwell *et al*. (1980).
[3]This study.

Table 92. Concentration (μg/L) of dissolved Bi in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.67	1.5	0.94	0.27	0.81

[1]This study.

Table 93. Concentration (μg/L) of total Bi in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.35	1.4	0.82	0.33	0.77

[1]This study.

Table 94. Concentration (μg/L) of dissolved Cd in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	1.0	1.0	--	--	--
1963	1	2.0	2.0	--	--	--
1964	2	4.0	4.0	4.0	0.0	--
1965	2	13.	16.	14.	2.12	--
1966	3	9.0	9.0	9.0	0.0	9.0
1967	1	8.0	8.0	--	--	--
1968	3	8.0	8.0	8.0	0.0	8.0
1969	9	0.0	0.0	0.0	0.0	0.0
1970	19	0.0	0.0	0.0	0.0	0.0
1971	4	0.0	5.0	2.5	2.9	0.0
1972	16	0.20	1.0	0.90	0.27	1.0
1973	15	1.0	4.0	1.2	0.77	1.0
1974	44	0.0	2.0	0.86	1.0	0.0
1975	18	0.10	0.90	0.29	0.29	0.10
1976	6	0.10	0.40	0.17	0.12	0.10
1979	9	0.010	0.010	0.010	0.0	0.010
1980	1	1.0	1.0	--	--	--

detection or are suspiciously high. Similar data for total metal concentrations are available for sixteen years (Table 95). Except for 1974 and perhaps 1972, all medians are at the limit of detection or are suspiciously high. For the epilimnion, dissolved cadmium concentrations have been reported for four years (Table 96). The 1962 and 1963 medians are at the limit of detection. No trend was found. For epilimnetic total cadmium, concentrations have been reported for twelve years (Table 97). The medians for 1962, 1963, 1972 (n=105), 1973 (n=48), 1973 (n=8, median=0.10), 1974 (n=42), 1974 (n=43), 1975 (n=36), 1976 (n=4), 1977 (n=103), 1980, and 1981 (n=166) appear to be at the limit of detection. No significant trend was found.

Cobalt (Co)

For unknown depths, dissolved cobalt data are available for nine years (Table 98). All medians are suspiciously high or at the limit of detection. Total metal data are available for 1975 and 1978 (Table 99). The 1978 median is suspiciously high. The 1975 data appear to have been entered into STORET as mg/L instead of as μg/L. Epilimnetic dissolved cobalt data are available for six years (Table 100). The 1971, 1974, and 1975 data are suspiciously high. No trend was found. Epilimnetic total metal data are available for four years (Table 101). The 1974 and 1977 data are at the limit of detection. The 1972 data also appear to be at the limit of detection. No trend could be calculated.

Chromium (Cr)

For unknown depths, dissolved chromium data are available for eleven years (Table 102). The 1968 and 1976 data appear to be at the limit of detection. The 1969 data appear to have been entered into STORET as mg/L instead of as μg/L. Total metal data are available for seventeen years (Table 103).

Table 95. Concentration (μg/L) of total Cd in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1966	2	0.0	0.0	0.0	0.0	--
1967	3	0.0	0.0	0.0	0.0	0.0
1968	13	0.0	30.	4.8	9.5	0.0
1969	15	0.0	20000.	8000.	10000.	0.0
1970	10	0.0	2.1	0.51	0.67	0.0
1971	17	0.0	10.	8.1	3.6	10.
1972	256	0.10	40.	3.2	5.0	0.20
1973	91	10.	20.	10.	1.0	10.
1974	367	0.020	50.	1.8	4.4	0.040
1975	97	0.020	10.	6.3	4.7	10.
1976	387	0.0	95.	4.7	8.2	2.0
1977	73	0.10	10.	6.8	4.3	10.
1978	47	0.50	110.	7.1	16.	1.0
1979	43	0.010	2.0	0.56	0.54	1.0
1980	22	2.0	10.	2.4	1.7	2.0
1981	31	0.60	31.	3.7	5.7	2.0

Table 96. Concentration (μg/L) of dissolved Cd in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	153	0.0	0.0	0.0	0.0	0.0
1963	83	0.0	0.0	0.0	0.0	0.0
1971	3	0.40	0.70	0.53	0.15	0.50
1981[1]	11	0.027	0.19	0.056	0.044	0.045

[1]This study.

Table 97. Concentration (μg/L) of total Cd in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	44	0.0	0.0	0.0	0.0	0.0
1963	3	0.0	0.0	0.0	0.0	0.0
1970	53	0.0	3.6	0.60	0.83	0.20
1972[1]	4	0.10	0.50	0.30	0.18	0.20
1972[2]	105	0.10	2.5	0.25	0.33	0.10
1973[3]	8	0.10	0.20	0.12	0.046	0.10
1973[4]	8	1.0	1.3	1.2	0.10	1.2
1973[5]	6	0.10	1.0	0.37	0.33	0.30
1973[6]	48	0.10	0.90	0.14	0.14	0.10
1974	42	0.10	97.	2.8	15.	0.10
1974[7]	76	1.0	33.	2.7	4.1	1.0
1974[8]	48	0.020	0.25	0.059	0.058	0.030
1974[3,9]	43	0.10	0.80	0.18	0.17	0.10
1974[10]	12	0.080	1.3	0.42	0.35	0.25
1975	11	0.080	0.20	0.19	0.036	0.20
1975[10]	12	0.020	5.6	1.10	1.8	0.16
1975[9,11]	36	0.10	0.50	0.12	0.070	0.10
1976	4	0.20	0.70	0.32	0.25	0.20
1976[11]	27	0.10	9.0	0.80	1.7	0.30
1976[10]	11	0.020	16.	2.5	5.3	0.19
1977[10]	6	0.010	0.38	0.18	0.14	0.13
1977[12]	103	<2.0	4.0	<2.0	--	--
1978[13]	2	0.018	0.046	.032	.020	--
1980	121	1.0	2.0	1.0	0.23	1.0
1981	166	1.0	3.0	1.0	0.22	1.0
1981[14]	11	0.019	0.087	0.042	0.018	0.044
1982	2	1.5	2.2	1.8	0.49	--

[1]Dacone (1973).
[2]Briars (1973).
[3]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[4]Wiersma (1974).
[5]Katnik and Redmond (1974).
[6]Gara and Hawley (1974).
[7]Texas Instruments Incorporated (1975).
[8]Industrial Bio-test Laboratories, Inc. (1975).
[9]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[10]Ellis (1977).
[11]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[12]Rockwell *et al*. (1980).
[13]Muhlbaier and Tisue (1981).
[14]This study.

Table 98. Concentration (μg/L) of dissolved Co in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	3.0	3.0	3.0	--	--
1963	1	2.0	2.0	2.0	--	--
1964	2	4.0	4.0	4.0	0.0	--
1965	2	9.0	9.0	9.0	0.0	--
1966	3	9.0	9.0	9.0	0.0	9.0
1967	1	8.0	8.0	8.0	--	--
1968	3	8.0	8.0	8.0	0.0	8.0
1970	6	0.	1.0	0.33	0.52	0.
1980	1	0.	0.	0.	--	--

Table 99. Concentration (μg/L) of total Co in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1975	8	.0050	.12	.020	.040	.0050
1978	3	1.0	5.0	3.7	2.3	5.0

Table 100. Concentration (µg/L) of dissolved Co in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	31	0.033	0.57	0.22	0.16	0.16
1970[1]	23	0.044	0.35	0.13	0.066	0.11
1971	2	0.40	1.4	0.90	0.71	—
1974[2]	52	0.083	2.8	1.1	0.57	1.0
1975[2]	36	0.41	2.4	1.3	0.52	1.2
1981[3]	11	0.035	0.093	0.053	0.020	0.049

[1]Copeland and Ayers (1972).
[2]Rossmann (1980).
[3]This study.

Table 101. Concentration (µg/L) of total Co in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	1.0	3.0	1.1	0.36	1.0
1974	40	10.	10.	10.	0.0	10.0
1977[2]	102	<1.0	2.0	<1.0	--	--
1981[2]	11	0.038	0.10	0.070	0.022	0.064

[1]Katnik and Redmond (1974).
[2]Rockwell *et al*. (1980).
[3]This study.

Table 102. Concentration (μg/L) of dissolved Cr in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	1.0	1.0	--	--	--
1963	1	4.0	4.0	--	--	--
1964	2	2.0	2.0	2.0	0.0	--
1965	2	4.0	4.0	4.0	0.0	--
1966	3	5.0	5.0	5.0	0.0	--
1967	1	4.0	4.0	--	--	--
1968	3	4.0	4.0	4.0	0.0	4.0
1969	4	0.010	0.020	0.012	0.0050	0.010
1975	18	1.0	3.0	2.4	0.92	3.0
1976	6	2.0	4.0	2.7	0.82	2.0
1980	1	4.0	4.0	--	--	--

Table 103. Concentration (μg/L) of total Cr in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1966	3	0.0	0.0	0.0	0.0	0.0
1967	3	0.0	20.	10.	10.	10.
1968	14	0.0	40.	6.8	14.	0.0
1969	10	0.0	32.	8.6	11.	0.0
1970	9	0.0	35.	6.5	11.	2.0
1971	16	0.0	30.	25.	9.7	30.
1972	292	1.0	380.	13.	32.	2.0
1973	178	0.0	940.	29.	92.	10.
1974	393	0.0	50.	3.4	6.2	0.90
1975	99	0.013	50.	9.2	8.0	10.
1976	387	0.0	1800.	17.	92.	10.
1977	75	1.0	120.	9.9	14.	10.
1978	67	1.0	840.	24.	100.	10.
1979	64	0.010	3.0	0.53	0.77	0.010
1980	44	5.0	20.	11.	3.3	10.
1981	52	3.0	410.	23.	64.	10.
1982	1	300.	300.	--	--	--

Except for 1970, 1972, 1974, and 1979, all data are either at the limit of detection or are suspiciously high. The 1979 data appear to have been entered into STORET as mg/L rather than as μg/L. For the epilimnion, dissolved chromium data are available for eight years (Table 104). The 1962 and 1963 medians are at the limit of detection. Dissolved chromium concentrations are decreasing at the rate of 0.0796 μg/L/y (r=0.91). Epilimnetic total chromium data are available for ten years (Table 105). The 1962, 1963, 1970, 1973 (n=6), 1973 (n=8), and 1975 (n=36) medians appear to be at the limit of detection. No significant trend was found.

Copper (Cu)

For samples collected from an unknown depth, dissolved copper data are available for seventeen years (Table 106). The 1966, 1968, 1973, and 1975 medians are suspiciously high. The 1967, 1969, 1970, 1971, 1974, and 1979 medians are at the limit of detection. The 1979 data appear to have been input to STORET as mg/L rather than as μg/L. Total metal data are available for sixteen years (Table 107). The 1969, 1970, 1971, 1973, 1975, 1976, 1977, 1978, and 1980 medians are suspiciously high. The 1966, 1967, and 1979 medians are at the limit of detection. A portion of the 1971 and 1975 data and all of the 1979 data appear to have been input to STORET as mg/L rather than as μg/L. For samples collected from the epilimnion, dissolved copper information exists for eight years (Table 108). The 1969, 1970 (n=8), and 1971 data are suspiciously high. The 1962 and 1963 medians are at the limit of detection. The 1962 and 1963 data appear to have been input to STORET as mg/L rather than as μg/L. Dissolved copper appears to be decreasing at the rate of 1.09 μg/L/y (r=0.86). Total copper data are available for twelve years (Table 109). The 1972 (n=4),

Table 104. Concentration (μg/L) of dissolved Cr in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	153	0.0	0.50	0.0036	0.040	0.0
1963	83	0.0	0.0090	0.00017	0.0011	0.0
1969[1]	31	0.50	4.0	1.8	0.75	1.7
1970[1]	23	0.84	2.2	1.6	0.31	1.6
1971	2	1.2	1.8	1.5	0.42	--
1974[2]	52	0.53	3.5	1.8	0.63	1.6
1975[2]	36	0.69	3.7	1.6	0.63	1.5
1981[3]	11	0.29	1.4	0.64	0.31	0.68

[1]Copeland and Ayers (1972).
[2]Rossmann (1980).
[3]This study.

Table 105. Concentration (μg/L) of total Cr in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	44	0.0	0.0	0.0	0.0	0.0
1963	3	0.0	0.0	0.0	0.0	0.0
1970	53	0.0	63.	4.2	11.	0.0
1973[1]	6	5.0	5.0	5.0	0.0	5.0
1973[2]	8	10.	10.	10.	0.0	10.
1973[3]	48	1.0	4.0	1.9	0.79	2.0
1974	42	0.60	1000.	34.	160.	0.90
1974[4]	64	2.0	7.0	3.1	1.2	3.0
1974[5]	48	0.10	2.4	0.93	0.51	0.90
1974[1,6]	39	1.0	5.0	3.0	1.6	2.0
1975	11	3.0	70.	16.	23.	5.0
1975[6,7]	36	1.0	5.0	1.8	1.3	1.0
1976	4	3.0	16.	7.0	6.0	4.0
1976[7]	30.	1.0	17.	4.3	5.6	2.0
1980	121	1.0	32.	2.5	3.7	2.0
1981	167	1.0	13.	2.4	1.5	2.0
1981[8]	11	0.53	0.84	0.68	0.097	0.68
1982	2	3.0	8.0	5.5	3.5	--

[1]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[2]Wiersma (1974).
[3]Gara and Hawley (1974).
[4]Texas Instruments Incorporated (1975).
[5]Industrial Bio-Test Laboratories, Inc. (1975).
[6]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[7]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[8]This study.

Table 106. Concentration (μg/L) of dissolved Cu in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	3.0	3.0	--	--	--
1963	1	2.0	2.0	--	--	--
1964	2	2.0	3.0	2.5	0.71	--
1965	2	3.0	7.0	5.0	2.8	--
1966	3	29.	34.	31.	2.9	29.
1967	11	0.0	14.	1.3	4.2	0.0
1968	4	0.0	12.	8.8	5.8	11.
1969	17	0.0	300.	21.	72.	0.0
1970	14	0.0	20.	5.0	8.5	0.0
1971	4	0.0	0.0	0.0	0.0	0.0
1972	16	1.0	60.	10.	14.	6.0
1973	15	2.0	86.	15.	21.	13.
1974	44	0.0	64.	6.2	12.	0.0
1975	18	1.0	80.	16.	18.	10.
1976	6	2.0	17.	6.3	5.8	3.0
1979	19	0.020	0.020	0.020	0.0	0.020
1980	1	4.0	4.0	--	--	--

Table 107. Concentration (μg/L) of total Cu in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1966	3	0.0	50.	17.	29.	0.0
1967	3	0.0	0.0	0.0	0.0	0.0
1968	14	0.0	60.	13.	17.	3.0
1969	16	10.	30000.	8100.	11000.	25.
1970	10	0.0	130.	26.	40.	12.
1971	17	0.040	100.	29.	24.	30.
1972	244	0.70	300.	16.	31.	3.6
1973	91	20.	130.	41.	25.	30.
1974	368	0.80	150.	7.6	15.	1.9
1975	101	0.0090	520.	31.	59.	20.
1976	412	0.0	80.	14.	11.	10.
1977	140	0.0	130.	39.	32.	30.
1978	65	3.0	500.	29.	60.	20.
1979	64	0.020	66.	6.2	14.	0.020
1980	45	2.0	72.	17.	16.	9.0
1981	54	3.0	170.	16.	28.	5.0

Table 108. Concentration (µg/L) of dissolved Cu in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	153	0.0	0.014	0.00023	0.0016	0.0
1963	83	0.0	0.018	0.0030	0.0038	0.0
1969[1]	9	9.0	18.	14.	3.2	14.
1970	2	1.0	5.0	3.0	2.8	--
1970[1]	8	7.0	14.6	28.	48.	8.0
1971	3	0.90	27.	13.	13.	11.
1974[2]	52	0.92	7.5	2.5	1.4	1.9
1975[2]	36	0.94	3.5	2.2	0.68	2.1
1981[3]	11	0.19	1.2	0.42	0.28	0.32

[1]Copeland and Ayers (1972).
[2]Rossmann (1980).
[3]This study.

Table 109. Concentration (μg/L) of total Cu in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	44	0.0	0.020	0.00084	0.0035	0.0
1963	3	0.0	0.0050	0.0017	0.0029	0.0
1970	54	0.0	14.	4.1	3.4	3.2
1972[1]	4	8.0	30.	20.	9.2	18.
1972[2]	105	1.0	20.	4.0	2.6	3.4
1973[3]	6	5.0	5.0	5.0	0.0	5.0
1973[4]	8	6.0	8.1	6.9	0.77	6.6
1973[5]	6	1.3	9.1	4.9	2.9	4.6
1973[6]	48	0.70	2.8	1.5	0.45	1.5
1974	42	2.0	68.	4.3	11.	2.0
1974[7]	76	1.0	10.	3.3	1.6	3.0
1974[8]	48	0.90	3.6	1.8	0.60	1.6
1974[3,9]	40	1.7	7.0	3.8	1.2	3.2
1974[10]	12	1.2	20.	5.1	6.6	2.6
1975	9	2.6	34.	20.	8.3	20.
1975[10]	12	0.70	12.	4.2	3.8	2.8
1975[9,11]	36	1.0	11.	2.6	2.5	2.0
1976	4	30.	34.	32.	1.7	32.
1976[10]	11	0.10	30.	6.3	8.9	1.3
1976[11]	30	1.0	6.0	2.1	1.5	1.0
1977[10]	6	1.1	24.	6.1	8.9	2.0
1977[12]	102	<1.0	9.0	1.8	1.3	--
1980	125	1.0	2600.	37.	280.	2.0
1981	170	1.0	38.	2.5	4.0	1.0
1981[13]	11	0.16	0.72	0.41	0.18	0.39
1982	1	3.0	3.0	--	--	--

[1]Dacone (1973).
[2]Briars (1973).
[3]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[4]Wiersma (1974).
[5]Katnik and Redmond (1974).
[6]Gara and Hawley (1974).
[7]Texas Instruments Incorporated (1975).
[8]Industrial Bio-Test Laboratories, Inc. (1975).
[9]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[10]Ellis (1977).
[11]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[12]Rockwell et al. (1980).
[13]This study.

1975 (n=9), and 1976 (n=4) data are suspiciously high. The 1962, 1963, 1973 (n=6, m=5.0), 1976 (n=39), and 1981 (n=170) medians appear to be at the limit of detection. Again, the 1962 and 1963 STORET data appear to have been entered as mg/L rather than as μg/L. No significant trend was found.

Iron (Fe)

For unknown depths, dissolved iron data are available for eleven years (Table 110). The 1968 and 1972 medians are at the limit of detection. The 1969 and 1970 data are suspiciously high. The 1977 data may have been input to STORET as mg/L rather than as μg/L. Total metal data are available for twenty years (Table 111). Except for 1962, 1964, 1965, 1978, 1979, 1980, and 1981, all medians are suspiciously high. Some of the 1975 and perhaps 1979 data may have been input to STORET as mg/L rather than as μg/L. Epilimnetic dissolved iron are identifiable for eight years (Table 112). No significant trend was found. Epilimnetic total iron data are available for eleven years (Table 113). The 1972 (n=4), 1973 (n=1), 1973 (n=8), 1973 (n=20), 1974 (n=42), 1974 (n=12), 1975, 1976 (n=30), 1976 (n=11), and 1977 data are suspiciously high or medians appear to be at the limit of detection. As for dissolved iron, no significant trend was found.

Mercury (Hg)

Dissolved mercury data for samples collected from an unknown depth are available for 1970 and 1980 (Table 114). Total mercury data are available for twelve years (Table 115). The 1970 median is suspiciously high. Epilimnetic dissolved mercury concentrations are available for four years (Table 116). The 1971 data are suspiciously high. The distribution of data points with time is skewed; thus any calculated trend should be used with caution. Dissolved

Table 110. Concentration (µg/L) of dissolved Fe in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1968	32	0.0	150.	31.	52.	0.0
1969	31	0.0	500.	110.	120.	100.
1970	20	0.0	970.	280.	300.	150.
1971	34	0.0	860.	160.	200.	70.
1972	466	0.0	260.	18.	32.	0.0
1973	56	0.0	130.	47.	49.	10.
1974	19	7.0	45.	17.	12.	12.
1975	18	14.	120.	31.	25.	24.
1976	7	8.0	40.	19.	11.	20.
1977	1	0.10	0.10	--	--	--
1980	1	1.0	1.0	--	--	--

Table 111. Concentration (μg/L) of total Fe in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	34.	34.	--	--	--
1963	7	0.0	1300.	460.	590.	200.
1964	2	7.0	16.	12.	6.4	--
1965	2	22.	37.	30.	11.	--
1966	69	5.0	22000.	950.	2700.	350.
1967	135	0.0	7800.	580.	840.	300.
1968	21	0.0	3400.	480.	800.	300.
1969	24	0.0	660.	250.	180.	200.
1970	24	28.	500.	170.	130.	100.
1971	17	0.0	560.	200.	180.	180.
1972	289	0.0	6200.	460.	710.	200.
1973	222	0.60	5000.	710.	640.	500.
1974	395	0.0	30000.	280.	1500.	100.
1975	96	0.021	3800.	350.	590.	200.
1976	101	12.	3800.	340.	530.	100.
1977	121	7.0	1800.	210.	340.	100.
1978	209	10.	24000.	180.	1700.	17.
1979	115	0.20	430.	44.	74.	15.
1980	177	10.	130.	32.	27.	18.
1981	160	10.	3400.	130.	420.	19.

Table 112. Concentration (μg/L) of dissolved Fe in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	31	5.2	56.	21.	13.	18.
1970	179	1.0	70.	19.	11.	20.
1970[1]	23	5.1	35.	16.	7.8	15.
1971	166	2.5	40.	13.	5.8	10.
1972	146	10.	60.	22.	11.	20.
1973	1	10.	10.	--	--	--
1974[2]	83	3.0	180.	39.	45.	20.
1974[3]	52	2.2	20.	8.1	3.3	7.1
1975[3]	36	1.6	12.	4.7	2.1	4.6
1981[4]	11	0.46	28.	4.9	7.9	2.5

[1]Copeland and Ayers (1972).
[2]Texas Instruments Incorporated (1975).
[3]Rossmann (1980).
[4]This study.

Table 113. Concentration (μg/L) of total Fe in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	7.0	7.0	--	--	--
1970	187	10.	300.	60.	56.	40.
1971	186	10.	270.	27.	23.	20.
1972	155	10.	250.	64.	48.	50.
1972[1]	4	260.	1100.	670.	380.	470.
1972[2]	105	19.	620.	140.	160.	47.
1973	1	980.	980.	--	--	--
1973[3]	8	100.	300.	150.	76.	100.
1973[4]	20	300.	1900.	720.	420.	600.
1973[5]	6	17.	2000.	370.	800.	52.
1973[6]	48	1.0	640.	75.	120.	40.
1974	42	5.0	1900.	100.	400.	10.
1974[3,7]	42	100.	600.	200.	110.	200.
1974[8]	12	140.	8400.	1600.	3000.	310.
1974[9]	79	3.0	200.	44.	51.	23.
1974[10]	48	9.0	550.	100.	110.	73.
1975	1	120.	120.	--	--	--
1975[8]	12	24.	3600.	910.	1100.	280.
1975[7,11]	36	100.	500.	170.	130.	100.
1976	49	6.0	620.	110.	130.	54.
1976[8]	11	54.	5700.	1400.	2100.	230.
1976[11]	30	100.	900.	240.	200.	100.
1977[8]	6	14.	3600.	740.	1400.	140.
1980	121	14.	430.	65.	73.	42.
1981	166	11.	620.	120.	120.	75.
1981[12]	11	3.5	93.	33.	30.	19.

[1]Dacone (1973).
[2]Briars (1973).
[3]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[4]Wiersma (1974).
[5]Katnik and Redmond (1974).
[6]Gara and Hawley (1974).
[7]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[8]Ellis (1977).
[9]Texas Instruments Incorporated (1975).
[10]Industrial Bio-Test Laboratories, Inc. (1975).
[11]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[12]This study.

Table 114. Concentration (μg/L) of dissolved Hg in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	5	0.0	0.30	0.12	0.13	0.10
1980	1	0.10	0.10	0.10	—	--

Table 115. Concentration (μg/L) of total Hg in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	32	0.0	32.	4.3	6.2	2.0
1971	99	0.0	6.1	0.90	0.93	0.70
1972	579	0.0	8.0	0.40	1.0	0.050
1973	354	0.0	2.9	0.080	0.26	0.0
1974	555	0.0	200.	0.46	8.5	0.060
1975	265	0.0	3.0	0.10	0.27	0.0
1976	592	0.0	3.0	0.064	0.18	0.0
1977	103	0.0	3.2	0.19	0.34	0.10
1978	66	0.10	2.0	0.27	0.27	0.20
1979	66	0.10	0.60	0.15	0.088	0.10
1980	55	0.010	1.0	0.16	0.15	0.10
1981	55	0.10	0.30	0.10	0.030	0.10

Table 116. Concentration (μg/L) of dissolved Hg in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	25	0.013	0.052	0.024	0.010	0.023
1970[1]	19	0.011	0.068	0.030	0.016	0.023
1971	3	0.10	0.30	0.23	0.11	0.28
1981[2]	11	−0.00060	0.12	0.044	0.033	0.048

[1]Copeland and Ayers (1972).
[2]This study.

mercury is decreasing at the rate of 0.00216 µg/L/y ($r=1.0$). Epilimnetic total mercury data are available for nine years (Table 117). The 1973 ($n=48$), 1974, 1976 ($n=4$), 1976 ($n=39$), 1977, 1980, and 1981 ($n=166$) medians appear to be at the limit of detection. No significant trend was found.

Lithium (Li)

For an unknown collection depth, dissolved lithium data are available for three years (Table 118). The 1976 data may be at the limit of detection. Total metal data are available for five years (Table 119). The 1976 median may be at the limit of detection. For the epilimnion, dissolved lithium concentrations are available for 1971 and 1981 (Table 120). Too few data are available for calculation of a trend. Likewise, total metal data are only available for 1972 and 1981 (Table 121), and no trend was calculated.

Manganese (Mn)

Unknown depth dissolved manganese data are available for seven years (Table 122). Most data are suspiciously high and the remainder have medians which appear to be at the limit of detection. Total manganese data have been found for twenty years (Table 123). The 1967 and 1970 and perhaps 1973 and 1981 medians appear to be at the limit of detection. Some of the 1969 data are erroneously high; perhaps improperly input into STORET. Some of the 1979 data appear to have been input to STORET as mg/L rather than as µg/L. Epilimnetic dissolved manganese data are available for six years (Table 124). No significant trend was found. Epilimnetic total metal data exist for eight years (Table 125). The 1972 ($n=105$) median appears to be at the limit of detection. No significant trend was found.

Table 117. Concentration (μg/L) of total Hg in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	28	0.0	0.70	0.31	0.26	0.50
1972[1]	4	0.050	0.21	0.14	0.066	0.13
1972[2]	75	0.050	3.3	0.43	0.49	0.32
1973[3]	8	0.50	1.2	0.86	0.21	0.80
1073[4]	8	0.13	0.21	0.19	0.027	0.19
1973[5]	6	0.050	13.	2.9	5.2	0.11
1973[6]	48	0.050	2.9	0.14	0.41	0.050
1974[3,7]	38	0.20	2.3	0.65	0.40	0.60
1974[8]	12	0.050	1.4	0.48	0.48	0.28
1974[9]	57	0.2	3.3	0.50	0.57	0.20
1974[10]	48	0.050	0.37	0.10	0.074	0.070
1974	2	0.50	0.50	0.50	0.0	--
1975	9	0.050	0.30	0.19	0.063	0.20
1975[8]	12	0.050	5.4	0.73	1.5	0.090
1975[7,11]	36	0.20	0.80	0.41	0.17	0.40
1976	4	0.20	0.20	0.20	0.0	0.20
1976[8]	11	0.050	9.7	1.0	2.9	0.10
1976[11]	30	0.20	2.2	0.54	0.55	0.20
1977[8]	6	0.050	0.22	0.087	0.068	0.050
1980	121	0.10	0.30	0.11	0.038	0.10
1981	166	0.10	0.20	0.10	0.0078	0.10
1981[12]	11	0.0075	0.11	0.052	0.031	0.045

[1]Dacone (1973).
[2]Briars (1973).
[3]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[4]Wiersma (1974).
[5]Katnik and Redmond (1974).
[6]Gara and Hawley (1974).
[7]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[8]Ellis (1977).
[9]Texas Instruments Incorporated (1975).
[10]Industrial Bio-Test Laboratories, Inc. (1975).
[11]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[12]This study.

Table 118. Concentration (μg/L) of dissolved Li in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1975	17	2.0	3.0	2.6	0.49	3.0
1976	6	2.0	2.0	2.0	0.0	2.0
1980	1	3.0	3.0	3.0	--	--

Table 119. Concentration (μg/L) of total Li in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1976	18	2.0	20.	4.2	5.8	2.0
1977	26	1.0	3.0	2.0	0.54	2.0
1978	26	1.0	3.0	1.6	0.64	1.0
1979	23	1.0	3.0	1.9	0.55	2.0
1980	1	2.0	2.0	2.0	--	--

Table 120. Concentration (μg/L) of dissolved Li in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1971	4	0.80	2.0	1.4	0.50	1.2
1981[1]	11	1.3	2.6	2.1	0.44	2.2

[1]This study.

Table 121. Concentration (μg/L) of total Li in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	3.0	5.0	4.0	1.0	3.5
1981[2]	11	1.3	2.6	2.1	0.44	2.2

[1]Briars (1973).
[2]This study.

Table 122. Concentration (μg/L) of dissolved Mn in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1971	2	0.	80.	40.	56.	--
1972	9	2.0	5.0	4.3	1.3	5.0
1973	15	3.0	10.0	7.6	3.1	10.0
1974	20	1.0	9.0	2.9	1.9	2.0
1975	18	1.0	8.0	2.0	2.1	1.0
1976	6	1.0	2.0	1.5	0.55	1.0
1980	1	0.	0.	0.	--	--

Table 123. Concentration (μg/L) of total Mn in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	0.30	0.30	0.30	--	--
1963	1	0.70	0.70	0.70	--	--
1964	2	1.0	2.1	1.6	0.78	--
1965	2	1.7	2.3	2.0	0.42	--
1966	6	0.	20.	5.8	7.5	2.8
1967	14	0.	50.	3.8	13.	0.
1968	18	0.	84.	27.	28.	11.
1969	26	0.	60000.	5400.	13000.	40.
1970	22	0.	330.	25.	72.	0.
1971	18	0.	40.	32.	14.	40.
1972	255	1.0	70.	8.9	12.	2.0
1973	93	20.	170.	42.	34.	20.
1974	392	0.	510.	15.	35.	3.7
1975	88	5.0	530.	51.	65.	30.
1976	438	2.0	200.	29.	23.	20.
1977	110	1.0	180.	37.	38.	20.
1978	58	2.0	482.	43.	74.	20.
1979	53	0.020	19.	3.3	5.4	.030
1980	25	10.	40.	21.	5.2	20.
1981	45	20.	200.	51.	48.	20.

Table 124. Concentration ($\mu g/L$) of dissolved Mn in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	31	0.27	2.6	0.94	0.62	0.87
1970[1]	23	0.0	2.6	0.86	0.62	0.77
1971	3	0.10	0.70	0.37	0.30	0.30
1974[2]	52	0.12	0.89	0.42	0.18	0.43
1975[2]	36	0.21	4.5	0.67	0.75	0.46
1981[3]	11	0.034	0.91	0.28	0.31	0.15

[1]Copeland and Ayers (1972).
[2]Rossmann (1980).
[3]This study.

Table 125. Concentration (μg/L) of total Mn in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1970	1	1.0	1.0	1.0	--	--
1972[1]	2	4.0	16.	10.	8.5	--
1972[2]	105	1.0	12.	2.7	2.7	1.0
1973[3]	8	1.0	6.0	3.2	2.1	2.0
1973[4]	8	11.5	13.	12.	0.51	12.
1973[5]	6	2.0	76.	16.	29.	5.0
1973[6]	48	1.0	9.0	3.2	1.8	3.0
1974	42	0.30	150.	6.3	25.	0.80
1974[7]	83	1.0	95.	8.5	12.	5.0
1974[8]	48	0.80	2.6	3.9	4.6	2.4
1974[3,9]	45	1.7	12.	5.2	2.5	5.0
1974[10]	12	3.6	420.	73.	140.	9.0
1975	1	40.	40.	40.	--	--
1975[9,11]	36	1.0	10.	3.2	2.5	2.0
1975[10]	12	1.2	140.	48.	56.	3.7
1976[11]	27	1.0	16.	4.8	3.0	4.0
1976[10]	11	0.40	520.	84.	160.	11.
1977[10]	6	0.10	310.	58.	120.	7.7
1977[12]	103	<1.0	8.0	<1.0	--	--
1981	1	70.	70.	70.	--	--
1981[13]	11	0.25	54.	9.3	18.	0.52

[1]Dacone (1973).
[2]Briars (1973).
[3]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[4]Wiersma (1974).
[5]Katnik and Redmond (1974).
[6]Gara and Hawley (1974).
[7]Texas Instruments Incorporated (1975).
[8]Industrial Bio-Test Laboratories, Inc. (1975).
[9]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[10]Ellis (1977).
[11]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[12]Rockwell _et al_. (1980).
[13]This study.

Molybdenum (Mo)

For samples collected from unknown depths, dissolved molybdenum concentrations are available for seven years (Table 126). All data are suspiciously high. Total metal concentrations are available for only 1978 (Table 127). They are suspiciously high. For the epilimnion, dissolved molybdenum data are available for five years (Table 128). The medians for 1974 and 1975 are suspiciously high. No significant trend was found. Total metal data are available for three years (Table 129). No meaningful trend could be calculated because 1972 data are at the limit of detection.

Nickel (Ni)

For unknown depths, dissolved nickel data are available for sixteen years (Table 130). Except for 1962, 1963, 1972, and 1976, the medians appear to be at the limit of detection. Total metal data are available for sixteen years (Table 131). Except for 1968, 1970, and 1972, the medians are either suspiciously high or at the limit of detection. Some of the data for 1972, 1974, 1975, and 1977 appear to have been improperly input into STORET. Epilimnetic dissolved nickel data are available for seven years (Table 132). The 1962 and 1963 medians are at the limit of detection. Data for these years were probably improperly input to STORET as mg/L instead of as μg/L. No significant trend was found. Total nickel data are available for eleven years (Table 133). The 1962, 1963, 1972 (n=105), 1973 (n=3), 1973 (n=8), 1973 (n=48), 1974 (n=42), 1974 (n=35), 1975 (n=12), 1975 (n=36), 1976 (n=4), 1976 (n=30), and 1977 medians are at the limit of detection. The 1975 (n=9) median is suspiciously high. No significant trend was found.

Table 126. Concentration (μg/L) of dissolved Mo in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	11.	11.	11.	--	--
1963	1	4.0	4.0	4.0	--	--
1964	2	8.0	20.	14.	8.5	--
1965	2	17.	39.	28.	16.	--
1966	3	18.	130.	67.	56.	55.
1967	1	72.	72.	72.	--	--
1968	3	39.	92.	61.	28.	52.

Table 127. Concentration (μg/L) of total Mo in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	3	1.0	81.0	39.	40.	34.

Table 128. Concentration (μg/L) of dissolved Mo in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	6	1.1	4.8	2.7	1.5	2.0
1970[1]	9	1.3	4.3	2.2	0.95	1.9
1971	3	0.40	0.60	0.50	0.1	0.50
1974[2]	52	2.3	18.	8.8	3.7	8.5
1975[2]	36	5.8	40.	19.	8.0	18.
1981[3]	11	1.0	1.4	1.2	0.14	1.3

[1]Copeland and Ayers (1972).
[2]Rossmann (1980).
[3]This study.

Table 129. Concentration (μg/L) of total Mo in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	50.	50.	50.	0.0	50.
1977[2]	106	<1.0	4.0	2.4	—	—
1981[3]	11	0.76	1.8	1.1	0.31	1.0

[1]Briars (1973).
[2]Rockwell *et al*. (1980).
[3]This study.

Table 130. Concentration (μg/L) of dissolved Ni in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	1.0	1.0	--	--	--
1963	1	2.0	2.0	--	--	--
1964	2	4.0	4.0	4.0	0.0	--
1965	2	9.0	9.0	9.0	0.0	--
1966	3	9.0	9.0	9.0	0.0	9.0
1967	1	8.0	8.0	--	--	--
1968	3	8.0	10.	8.7	1.2	8.0
1969	14	0.0	20.	7.1	8.2	0.0
1970	14	0.0	0.0	0.0	0.0	0.0
1971	4	0.0	0.0	0.0	0.0	0.0
1972	16	2.0	5.0	4.6	1.0	5.0
1973	15	5.0	25.	6.3	5.2	5.0
1974	44	0.0	13.	2.3	3.0	0.0
1975	18	5.0	26.	9.2	5.9	5.0
1976	6	4.0	6.0	4.8	0.75	5.0
1980	1	0.0	0.0	--	--	--

Table 131. Concentration ($\mu g/L$) of total Ni in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1966	3	0.0	0.0	0.0	0.0	0.0
1967	3	0.0	50.	30.	26.	40.
1968	13	0.0	47.	16.	20.	1.0
1969	16	0.0	48.	14.	14.	16.
1970	10	1.4	28.	9.7	10.	3.6
1971	5	0.0	30.	15.	14.	9.0
1972	244	0.010	4.0	1.2	1.1	1.0
1973	91	0.020	0.16	0.033	0.022	0.030
1974	366	0.020	51.	2.3	5.1	1.0
1975	87	0.0040	20.	0.75	3.0	0.020
1976	387	0.0	2000.	15.	100.	10.
1977	74	0.020	28.	4.0	6.2	0.020
1978	29	2.0	95.	11.	18.	5.0
1979	23	5.0	5.0	5.0	0.0	5.0
1980	1	5.0	5.0	--	--	--
1981	28	10.	1600.	86.	310.	10.

Table 132. Concentration (μg/L) of dissolved Ni in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	153	0.0	0.0060	0.00046	0.0015	0.0
1963	83	0.0	0.015	0.00067	0.0024	0.0
1970	1	1.0	1.0	--	--	--
1971	3	0.40	10.	4.0	5.2	1.5
1974[1]	52.	2.1	19.	8.1	4.4	7.3
1975[1]	36	2.8	15.	6.5	2.0	6.4
1981[2]	11	0.34	0.98	0.63	0.17	0.64

[1]Rossmann (1980).
[2]This study.

Table 133. Concentration (μg/L) of total Ni in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	44	0.0	0.0070	0.0019	0.0026	0.0
1963	3	0.0	0.0060	0.0020	0.0035	0.0
1970	54	0.0	20.	3.4	3.8	2.8
1972[1]	2	3.0	4.0	3.5	0.71	--
1972[2]	105	1.0	4.0	1.5	0.64	1.0
1973[3]	3	5.0	10.	6.7	2.9	5.0
1973[4]	8	10.	10.	10.	0.0	10.
1973[5]	6	1.0	6.0	2.8	2.1	2.0
1973[6]	48	1.0	2.0	1.0	0.14	1.0
1974	42	5.0	150.	9.3	23.	5.0
1974[7]	83	1.0	22.	3.3	3.0	2.0
1974[8]	48	1.0	14.	2.2	2.7	1.0
1974[3,9]	35	5.0	6.0	5.1	0.24	5.0
1974[10]	12	1.0	18.	6.1	5.5	4.0
1975	9	3.0	20.	18.	5.7	20.
1975[10]	12	1.0	6.0	2.0	1.9	1.0
1975[9,11]	36	5.0	7.0	5.1	0.33	5.0
1976	4	20.	20.	20.	0.0	20.
1976[10]	11	1.0	27.	5.4	7.8	2.0
1976[11]	30	5.0	10.	5.5	1.4	5.0
1977[10]	6	1.0	9.0	2.8	3.2	1.0
1977[12]	102	<5.0	13.	<5.0	--	--
1981	1	20.	20.	--	--	--
1981[13]	11	0.45	0.87	0.64	0.14	0.60
1982	1	40.	40.	--	--	--

[1]Dacone (1973).
[2]Briars (1973).
[3]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[4]Wiersma (1974).
[5]Katnik and Redmond (1974).
[6]Gara and Hawley (1974).
[7]Texas Instruments Incorporated (1975).
[8]Industrial Bio-Test Laboratories, Inc. (1975).
[9]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[10]Ellis (1977).
[11]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[12]Rockwell _et al_. (1980).
[13]This study.

Lead (Pb)

For unknown depths, dissolved lead data are available for seventeen years (Table 134). The 1969, 1971, 1973, 1975, 1976, and 1979 medians are at the limit of detection. Except for 1979, all data are suspiciously high. The 1979 data may have been input improperly into STORET. Total lead concentrations have been found for sixteen years (Table 135). Except for those medians at the limit of detection and the 1979 data, all medians are suspiciously high. Some of the 1979 data may have been improperly input to STORET and the median is at the limit of detection. Epilimnetic dissolved lead data have been found for five years (Table 136). The 1970 and 1972 data are suspiciously high. The 1962 and 1963 data may have been improperly input to STORET and the medians are at the limit of detection. No trend exists. For total lead, data are available for thirteen years (Table 137). Except for 1981 (n=11), all medians are either suspiciously high or at the limit of detection. The 1962 and 1963 data appear to have been improperly input to STORET. No significant trend exists.

Antimony (Sb)

For unknown depths, only total antimony data for 1978 exist (Table 138). These data are suspiciously high. For the epilimnion, only dissolved historical data exist (Table 139). Because of the skewed occurrence of data by year, only a tentative dissolved antimony trend can be calculated. Dissolved antimony is increasing at a rate of 0.00173 $\mu g/L/y$ (r=1.0). The only total antimony data identified are those of this study (Table 140).

Table 134. Concentration (μg/L) of dissolved Pb in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	7.0	7.0	--	--	--
1963	1	4.0	4.0	--	--	--
1964	2	8.0	12.	10.	2.8	--
1965	2	17.	20.	18.	2.1	--
1966	3	18.	18.	18.	0.0	--
1967	1	16.	16.	--	--	--
1968	3	16.	28.	20.	6.9	16.
1969	5	0.0	0.0	0.0	0.0	0.0
1970	9	0.0	7.0	2.3	2.5	1.0
1971	4	0.0	0.0	0.0	0.0	0.0
1972	16	2.0	10.	5.9	3.8	5.0
1973	15	5.0	10.	5.3	1.3	5.0
1974	44	0.0	16.	3.7	4.2	5.0
1975	18	1.0	30.	5.8	8.3	1.0
1976	6	1.0	3.0	1.7	1.0	1.0
1979	19	0.020	0.020	0.020	0.0	0.020
1980	1	0.0	0.0	--	--	--

Table 135. Concentration (μg/L) of total Pb in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1966	3	0.0	0.0	0.0	0.0	0.0
1967	3	0.0	40.	20.	20.	20.
1968	14	0.0	60.	17.	18.	10.
1969	14	0.0	40000.	8600.	15000.	0.0
1970	10	0.0	49.	13.	16.	6.6
1971	17	0.0	50.	38.	15.	40.
1972	255	1.0	70.	9.0	11.	3.0
1973	91	20.	70.	28.	13.	20.
1974	368	1.0	70.	6.6	12.	1.0
1975	102	0.0020	60.	16.	13.	20.
1976	440	0.0	3500.	34.	170.	20.
1977	121	1.0	100.	38.	34.	20.
1978	68	4.0	320.	21.	37.	20.
1979	64	0.020	5.0	1.7	2.4	0.020
1980	54	5.0	20.	20.	2.0	20.
1981	61	3.0	39.	11.	5.3	10.

Table 136. Concentration (μg/L) of dissolved Pb in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	153	0.0	0.011	0.00048	0.0020	0.0
1963	83	0.0	0.080	0.0072	0.013	0.0
1970	2	1.0	2.0	1.5	0.71	--
1971	2	2.0	4.2	3.1	1.6	--
1981[1]	11	0.023	0.27	0.15	0.080	0.14

[1]This study.

Table 137. Concentration (μg/L) of total Pb in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	44	0.0	0.020	0.0019	0.0041	0.0
1963	3	0.0	0.0050	0.0017	0.0029	0.0
1970	68	0.0	110.	12.	21.	6.2
1971	9	5.0	9.0	6.5	1.6	6.0
1972[1]	4	3.0	10.	6.2	3.3	4.0
1972[2]	105	1.0	12.	3.0	2.1	3.0
1973[3]	7	1.0	3.0	1.7	0.76	2.0
1973[4]	8	10.	10.	10.	0.0	10.
1973[5]	48	1.0	33.	5.7	6.1	4.0
1974	42	1.0	80.	4.6	16.	1.0
1974[6]	83	0.0	17.	7.1	4.4	7.0
1974[7]	48	1.0	7.0	1.4	1.3	1.0
1974[3,8]	40	1.0	6.0	1.4	0.98	1.0
1974[9]	12	1.0	26.	5.1	7.5	2.0
1975	9	2.0	19.	13.	5.3	15.
1975[9]	12	1.0	18.	5.6	5.7	2.0
1975[8,10]	36	1.0	1.0	1.0	0.0	1.0
1976	4	7.0	150.	43.	71.	8.0
1976[9]	11	1.0	30.	6.7	9.5	1.0
1976[10]	30	1.0	170.	18.	44.	1.0
1977	1	110.	110.	--	--	--
1977[9]	6	1.0	20.	4.8	7.5	1.0
1977[11]	102	<6.0	19.	6.6	9.3	--
1980	121	1.0	20.	1.6	2.0	1.0
1981	167	1.0	32.	1.7	2.8	1.0
1981[12]	11	0.13	0.48	0.26	0.11	0.25
1982	1	5.0	5.0	--	--	--

[1]Dacone (1973).
[2]Briars (1973).
[3]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[4]Wiersma (1974).
[5]Gara and Hawley (1974).
[6]Texas Instruments Incorporated (1975).
[7]Industrial Bio-Test Laboratories, Inc. (1975).
[8]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[9]Ellis (1977).
[10]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[11]Rockwell et al. (1980).
[12]This study.

Table 138. Concentration (μg/L) of total Sb in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	2	3.0	10.	6.5	4.9	--

Table 139. Concentration (μg/L) of dissolved Sb in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	31	0.080	0.81	0.23	0.16	0.21
1970[1]	23	0.14	0.33	0.21	0.047	0.21
1981[2]	11	0.029	0.31	0.22	0.093	0.23

[1]Copeland and Ayers (1972).
[2]This study.

Table 140. Concentration (μg/L) of total Sb in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.056	0.34	0.23	0.092	0.25

[1]This study.

Selenium (Se)

Unknown depth dissolved selenium data have been found for eight years (Table 141). The 1973, 1974, 1975, and 1976 medians apear to be at the limit of detection. The 1962 and 1963 data appear to have been input to STORET as mg/L rather than as μg/L. Total metal data exist for ten years (Table 142). Except for 1977, 1978, and 1979, all medians are at the apparent limit of detection. Some of the 1978 data appear to have been improperly entered into STORET. Epilimnetic dissolved selenium data have been found for four years (Table 143). Except for 1981, all data are suspiciously low. Dissolved selenium is increasing at the rate of 0.252 μg/L/y (r=1.0). For total selenium, data exist for five years (Table 144). All medians except the 1981 (n=11) are at the limit of detection. No significant trend exists.

Tin (Sn)

For an unknown depth, only total metal data are available for 1978 (Table 145). They are suspiciously high. Epilimnetic dissolved (Table 146) and total tin (Table 147) data are available for 1972, 1974, and 1981, respectively. Except for 1981, all data are suspiciously high. For total Sn, no trend exists.

Strontium (Sr)

For unknown depths, only dissolved strontium data are available for eight years (Table 148). Except for 1967 and 1980, all data are suspiciously low. Epilimnetic dissolved strontium data are available for six years (Table 149). No significant trend exists. For total metal, data exist for 1972 and 1981 (Table 150). No attempt was made to postulate a trend from two data points.

Table 141. Concentration (μg/L) of dissolved Se in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	0.010	0.010	0.010	--	--
1963	1	0.010	0.010	0.010	--	--
1972	16	1.0	5.0	4.0	1.8	5.0
1973	15	1.0	2.0	1.2	0.41	1.0
1974	44	0.	1.0	0.43	0.50	0.0
1975	18	2.0	2.0	2.0	0.0	2.0
1976	6	2.0	2.0	2.0	0.0	2.0
1980	1	1.0	1.0	1.0	--	--

Table 142. Concentration (μg/L) of total Se in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1971	1	0.	0.	0.	--	--
1972	226	0.	0.	0.	0.0	0.0
1973	247	0.	0.	0.	0.0	0.0
1974	191	0.	3.	0.14	0.48	0.0
1975	179	0.	5.	0.35	1.11	0.0
1976	193	0.	2.0	0.14	0.45	0.0
1977	31	0.	2.0	1.0	0.60	1.0
1978	28	0.0050	20.	1.9	3.7	1.0
1979	23	0.40	1.0	0.90	0.23	1.0
1981	3	5.0	10.	6.7	2.9	5.0

Table 143. Concentration (μg/L) of dissolved Se in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	30	0.016	0.15	0.076	0.027	0.080
1970[1]	23	0.053	0.17	0.098	0.024	0.096
1974	3	0.10	0.10	0.10	0.0	0.10
1981[2]	11	1.7	3.7	2.6	0.76	3.0

[1]Copeland and Ayers (1972).
[2]This study.

Table 144. Concentration (μg/L) of total Se in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	1.0	10.	5.5	4.6	1.0
1974	40	2.0	2.0	2.0	0.0	2.0
1974[2]	48	0.80	8.0	2.4	3.1	0.80
1975	1	1.0	1.0	1.0	--	--
1980	121	1.0	1.0	1.0	0.0	1.0
1981	166	1.0	1.0	1.0	0.0	1.0
1981[3]	11	0.86	4.5	2.5	1.1	2.7

[1]Briars (1973).
[2]Industrial Bio-Test Laboratories, Inc. (1975).
[3]This study.

Table 145. Concentration (μg/L) of total Sn in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	3	18.	250.	120.	120.	85.

Table 146. Concentration (μg/L) of dissolved Sn in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1981[1]	11	0.15	10.	2.6	3.6	1.5

[1]This study.

Table 147. Concentration (μg/L) of total Sn in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	100.	200.	130.	45.	100.
1974	40	100.	120.	110.	2.2	110.
1981[2]	11	0.033	7.3	3.4	2.6	2.6

[1]Briars (1973).
[2]This study.

Table 148. Concentration (μg/L) of dissolved Sr in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	38.	38.	38.	--	--
1963	1	47.	47.	47.	--	--
1964	2	66.	66.	66.	0.0	--
1965	2	46.	64.	55.	13.	--
1966	3	52.	87.	68.	18.	66.
1967	1	110.	110.	110.	--	--
1968	3	29.	73.	55.	23.	62.
1980	1	120.	120.	120.	--	--

Table 149. Concentration (μg/L) of dissolved Sr in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	31	56.	140.	95.	20.	97.
1970[1]	23	64.	140.	100.	15.	100.
1971	4	100.	110.	110.	4.2	100.
1974[2]	52	40.	180.	110.	27.	100.
1975[2]	36	53.	140.	110.	21.	110.
1981[3]	11	87.	120.	110.	9.1	110.

[1]Copeland and Ayers (1972).
[2]Rossmann (1980).
[3]This study.

Table 150. Concentration (μg/L) of total Sr in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1972[1]	30	100.	100.	100.	0.0	100.
1981[2]	11	100.	120.	120.	5.3	120.

[1]Briars (1973).
[2]This study.

Vanadium (V)

For unknown depths, dissolved vanadium data exist for eight years (Table 151), and total metal data are available for 1978 (Table 152). Except for 1962 and 1980 dissolved metal data, all data are suspiciously high. Epilimnetic dissolved vanadium data are available for three years (Table 153). Because of the distribution and small number of data points, a tentative increase, at the rate of 0.008759 μg/L/y (r=1.0), exists for dissolved vanadium. Total vanadium data exist for five years (Table 154). The 1972, 1974, and 1977 medians or means are at the limit of detection. No concentration trend exists.

Zinc (Zn)

Unknown depth dissolved zinc data are available for sixteen years (Table 155). The 1967 and 1974 medians are at the limit of detection. All remaining data are suspiciously high. Total metal data exist for fifteen years (Table 156). All medians are suspiciously high. For the epilimnion, dissolved zinc data have been found for eight years (Table 157). Except for 1962, 1963, and 1981, all data are suspiciously high. The 1962 and 1963 data appear to have been improperly input into STORET. Total metal data exist for eleven years (Table 158). Except for the 1962 and 1963 data improperly input to STORET and the 1981 data, all data are suspiciously high. For both total and dissolved zinc, no significant trends were found.

Table 151. Concentration (μg/L) of dissolved V in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	1.0	1.0	1.0	--	--
1963	1	7.0	7.0	7.0	--	--
1964	2	8.0	8.0	8.0	0.0	--
1965	2	16.	17.	16.	0.71	--
1966	3	18.	18.	18.	0.0	18.
1967	1	16.	16.	16.	--	--
1968	3	16.	16.	16.	0.0	16.
1980	1	1.0	1.0	1.0	--	--

Table 152. Concentration (μg/L) of total V in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1978	3	1.0	30.	14.	15.	12.

Table 153. Concentration (μg/L) of dissolved V in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1969[1]	30	0.14	0.32	0.22	0.047	0.22
1970[1]	23	0.15	0.42	0.26	0.078	0.24
1981[2]	11	0.21	0.81	0.42	0.22	0.33

[1]Copeland and Ayers (1972).
[2]This study.

Table 154. Concentration (μg/L) of total V in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1971	1	0.30	0.30	0.30	--	--
1972[1]	30	100.	100.	100.	0.0	100.
1974	40	10.	10.	10.	0.0	10.
1974[2]	48	0.30	3.0	2.8	0.66	3.0
1977[3]	101	<10.	25.	<10.	--	--
1981[4]	11	0.26	1.2	0.54	0.28	0.48

[1]Briars (1973).
[2]Industrial Bio-Test Laboratories, Inc. (1975).
[3]Rockwell *et al*. (1980).
[4]This study.

Table 155. Concentration (μg/L) of dissolved Zn in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	1	10.	10.	10.	--	--
1963	1	2.0	2.0	.20	--	--
1964	2	5.0	13.	9.0	5.6	--
1965	2	12.	17.	14.	3.5	--
1966	3	10.	23.	17.	6.6	18.
1967	11	0.	8.0	0.73	2.4	0.
1968	4	0	23.	10.	9.6	8.0
1969	17	0.	480.	52.	110.	10.
1970	20	0.	130.	26.	31.	13.
1971	5	0.	55.	15.	23.	5.0
1972	16	7.0	210.	29.	52.	10.
1973	15	3.0	85.	28.	30.	15.
1974	44	0.	110.	7.9	18.	0.
1975	18	4.0	80.	25.	19.	16.
1976	6	5.0	85.	28.	34.	6.0
1980	1	0.	0.	0.	--	--

Table 156. Concentration (μg/L) of total Zn in Lake Michigan waters collected from an unknown depth.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1966	3	0.	30.	20.	17.	30.
1967	3	30.	50.	40.	10.	40.
1968	14	0.	102.	38.	33.	40.
1969	16	23.	210000.	43000.	69000.	77.
1970	10	0.	130.	26.	31.	57.
1971	17	10.	160.	38.	40.	30.
1972	244	1.0	640.	36.	63.	15.
1973	91	20.	240.	84.	50.	70.
1974	356	0.10	1800.	34.	120.	8.3
1975	86	.0090	17000.	230.	1800.	30.
1976	413	3.0	12000.	59.	590.	20.
1977	66	2.0	200.	22.	26.	20.
1978	29	1.0	1300.	99.	250.	15.
1979	23	1.0	170.	22.	43.	8.0
1980	9	5.0	10.	9.4	1.7	10.
1981	29	10.	7900.	350.	1500.	10.

Table 157. Concentration (μg/L) of dissolved Zn in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	153	0.	.032	.00088	.0041	0.0
1963	83	0.	.071	.0042	.012	0.0
1969[1]	31	1.9	41.	13.	11.	9.0
1970	1	2.0	2.0	2.0	--	--
1970[1]	23	3.0	80.	24.	23.	15.
1971	3	5.5	30.	14.	14.	7.0
1974[2]	52	1.1	11.	5.5	2.6	5.1
1975[2]	36	0.30	9.7	3.4	1.9	2.8
1981[3]	11	0.25	2.1	0.65	0.51	0.48

[1]Copeland and Ayers (1972).
[2]Rossmann (1980).
[3]This study.

Table 158. Concentration (μg/L) of total Zn in Lake Michigan waters collected from depths less than 5 m.

Year	Number of Samples	Minimum	Maximum	Mean	Standard Deviation	Median
1962	44	0.	.034	.0037	.0072	0.
1963	3	0.	.025	.0083	.014	0.
1970	54	2.0	1000.	63.	150.	29.
1972[1]	4	1.0	30.	18.	14.	14.
1972[2]	105	1.0	36.	12.	8.6	11.
1973[3]	7	2.0	25.	8.1	8.2	5.0
1973[4]	8	12.	17.	14.	1.8	14.
1973[5]	6	1.0	52.	22.	22.	6.0
1973[6]	48	1.0	78.	13.	15.	10.
1974	42	10.	660.	68.	143.	25.
1974[7]	83	1.0	52.	15.	13.	15.
1974[8]	48	1.7	150.	13.	22.	6.4
1974[3,9]	44	2.0	25.	7.9	5.4	7.0
1974[10]	12	6.5	100.	32.	34.	20.
1975	9	8.7	50.	29.	15.	20.
1975[10]	12	2.8	110.	31.	34.	14.
1975[9,11]	36	2.0	9.0	4.7	1.7	4.0
1976	4	40.	110.	68.	31.	50.
1976[10]	11	2.6	120.	31.	35.	24.
1976[11]	30	1.0	21.	11.	5.1	10.
1977	1	180.	180.	180.	--	--
1977[10]	6	3.8	75.	30.	29.	8.4
1977[12]	38	<3.0	25.	11.	3.4	--
1981	1	20.	20.	20.	--	--
1981[13]	11	0.37	1.1	0.62	0.19	0.59
1982	1	20.	20.	20.	--	--

[1]Dacone (1973).
[2]Briars (1973).
[3]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1975).
[4]Wiersma (1974).
[5]Katnik and Redmond (1974).
[6]Gara and Hawley (1974).
[7]Texas Instruments Incorporated (1975).
[8]Industrial Bio-Test Laboratories, Inc. (1975).
[9]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1976).
[10]Ellis (1977).
[11]Wisconsin Electric Power Company and Wisconsin Michigan Power Company (1977).
[12]Rockwell _et al_. (1980).
[13]This study.

DISCUSSION

Trace metal concentrations in Lakes Erie and Michigan are distinctly different for the two lakes. The two lakes are compared with respect to total and dissolved metal concentrations, metal partitioning, meeting International Joint Commission Water Quality Objectives, and the potential toxicity of metal mixtures. To provide a baseline to which these lakes can be compared, the Lake Huron trace metal data of Rossmann (1982) also will be presented.

DISSOLVED METAL CONCENTRATIONS

Median dissolved metal concentrations for Lakes Erie and Michigan have been summarized and compared with those of Lake Huron (Table 159). Aluminum, beryllium, cadmium, cobalt, copper, iron, manganese, nickel, strontium, and zinc concentrations are distinctly higher in Lake Erie than in Lake Michigan. Silver, arsenic, bismuth, chromium, mercury, lithium, antimony, selenium, and tin concentrations are higher in Lake Michigan than in Lake Erie. Except for manganese, dissolved metal concentrations in Lakes Erie and Michigan are higher than those in Lake Huron, reflecting the higher degree of industrialization of the Lakes Erie and Michigan basins.

TOTAL METAL CONCENTRATIONS

Median total metal concentrations for Lakes Erie and Michigan have been summarized and compared with those of Lake Huron (Table 160). Aluminum, barium, beryllium, cadmium, cobalt, copper, iron, manganese, molybdenum, nickel, lead, strontium, and zinc concentrations are higher in Lake Erie than in Lake Michigan. Silver, arsenic, bismuth, chromium, mercury, antimony, selenium, and tin concentrations are higher in Lake Michigan than in Lake Erie. Except for

Table 159. Median dissolved metal concentrations in the waters of Lakes Erie, Michigan, and Huron ($\mu g/L$).

Metal	Lake Erie (1981) n=11	Lake Michigan (1981) n=11	Lake Huron (1980)[1] n=23
Ag	0.035	0.050	0.0058
Al	22.	7.8	3.1
As	0.42	0.79	0.25
Ba	48.	46.	--
Be	0.017	0.0096	--
Bi	0.69	0.81	--
Cd	0.067	0.045	0.0
Co	0.089	0.049	--
Cr	0.27	0.68	0.11
Cu	0.70	0.32	0.28
Fe	13.	2.5	0.80
Hg	0.024	0.048	0.0042
Li	1.7	2.2	--
Mn	0.37	0.15	0.28
Mo	1.5	1.3	--
Ni	1.3	0.64	0.49
Pb	0.17	0.14	0.0089
Sb	0.17	0.23	--
Se	2.5	3.0	0.48
Sn	1.1	1.5	--
Sr	140.	110.	--
V	0.35	0.33	0.24
Zn	1.3	0.48	0.17

[1]Rossmann (1982).

Table 160. Median total metal concentrations in the waters of Lakes Erie, Michigan, and Huron (μg/L).

Metal	Lake Erie (1981) n=11	Lake Michigan (1981) n=11	Lake Huron (1980)[1] n=23
Ag	0.026	0.057	0.0090
Al	180.	40.	8.8
As	0.43	0.69	0.21
Ba	52.	45.	--
Be	0.032	0.016	--
Bi	0.58	0.77	--
Cd	0.072	0.044	0.015
Co	0.096	0.064	--
Cr	0.39	0.68	0.13
Cu	1.8	0.39	0.40
Fe	100.	75.	4.8
Hg	0.033	0.045	0.011
Li	2.0	2.2	--
Mn	12.	0.52	0.67
Mo	1.4	1.0	--
Ni	1.1	0.60	0.54
Pb	0.34	0.25	0.022
Sb	0.085	0.25	--
Se	2.1	2.7	0.48
Sn	1.4	2.6	--
Sr	140.	120.	--
V	0.42	0.48	0.22
Zn	1.2	0.59	0.29

[1]Rossmann (1982).

copper and manganese, Lakes Erie and Michigan total metal concentrations are higher than those of Lake Huron. Lakes Huron and Michigan copper and manganese concentrations are similar to and lower than those of Lake Erie.

ESTIMATED FRACTION OF TOTAL METAL IN PARTICULATES

To estimate the fraction of total metal resident in the particulate fraction (>0.5 μm diameter), the dissolved metal concentration was subtracted from the total metal concentration. This result was then divided by the total metal concentration and multiplied by 100 to convert to a percentage (Table 161). In both Lake Erie and Lake Michigan, large percentages of aluminum, iron, and manganese are associated with particulate matter. This is similar to what has been reported for Lake Huron (Rossmann 1982). A substantial fraction of the total beryllium, cobalt, copper, lead, tin, vanadium, and zinc are associated with Lake Michigan particulate matter. In Lake Erie, a substantial fraction of the total silver, beryllium, chromium, copper, mercury, lead, tin, and vanadium are associated with the particulate fraction. Both Lake Erie and Lake Michigan particulate fractions of cadmium, mercury, lead, and zinc are significantly lower than those of Lake Huron. Three of the eleven Lake Michigan samples were collected from Green Bay, and one sample was collected from the Straits of Mackinac. For Lake Michigan and especially Lake Erie, it appears as if a significant fraction of the particulates may have been resuspended sediment. This does not appear to be the case for Lake Huron and may explain the differences observed for the three lakes.

Table 161. Estimated fraction of total metal concentration existing as particulate matter in the waters of Lakes Erie, Michigan, and Huron.

	Percent		
Metal	Lake Erie	Lake Michigan	Lake Huron[1]
Ag	26.	12.	18.
Al	88.	80.	83.
As	2.3	0.0	3.0
Ba	7.7	0.0	--
Be	47.	40.	--
Bi	0.0	0.0	--
Ca	2.9	2.9	--
Cd	7.3	0.0	100.
Co	7.3	23.	--
Cr	31.	0.0	13.
Cu	61.	18.	30.
Fe	87.	87.	89.
Hg	27.	0.0	62.
K	8.3	9.1	--
Li	15.	0.0	--
Mg	9.1	0.0	--
Mn	97.	71.	67.
Mo	0.0	0.0	--
Na	2.3	0.0	--
Ni	0.0	0.0	6.0
Pb	50.	44.	82.
Sb	0.0	8.0	--
Se	0.0	0.0	0.0
Sn	21.	42.	--
Sr	0.0	8.3	--
V	17.	31.	6.0
Zn	0.0	19.	66.

[1]Rossmann (1982).

WATER QUALITY AGREEMENT OBJECTIVES AND OBSERVED METAL CONCENTRATIONS

To assess how well Water Quality Agreement Objectives for metals are being met in Lakes Erie and Michigan, a comparison was made between the objectives and the 1981 data. The existing objectives were previously summarized in Table 61. Table 162 contains the results of this comparison for Lakes Erie and Michigan as well as for Lake Huron as a point of reference. For Lake Erie, the exceeding of the Cd, Cu, and Fe objectives all occurred in the western basin where sediment resuspension occurred during the period of sampling. For Lake Michigan, the one occurrence of the silver objective being exceeded occurred in southern Lake Michigan at station 18. The two occurrences of mercury exceeding the objective for Lake Huron have been attributed to possible sample contamination (Rossmann 1982). The most startling difference between the lakes is the high occurrence of observations exceeding the proposed selenium objective for Lakes Erie and Michigan. For Lake Huron, the objective was exceeded in only 4% of the samples; however, it was exceeded in 82% of the samples collected from Lakes Erie and Michigan. In light of the proposed selenium objective, selenium contamination of Lakes Erie and Michigan is of great concern.

POTENTIAL TOXICITY OF METAL MIXTURES

Using the toxicity unit concept discussed earlier, the toxicity unit was calculated for the metals for which water quality objectives exist (Table 163). Metals which contribute heavily to the Lake Erie toxicity unit are silver, cadmium, copper, iron, and selenium. Those metals contributing significantly to the Lake Michigan toxicity unit are silver, cadmium, iron, mercury, and selenium. Because both of these lakes have a toxicity unit which exceeds 1.0, subtle adverse effects on the biota are expected to occur (Aquatic Ecosystem Objectives

Table 162. Occurrences of Lakes Erie, Michigan, and Huron metal concentrations in water equalling or exceeding Water Quality Agreement objectives.

	Lake Erie		Lake Michigan		Lake Huron[1]	
Metal	Number of Observations Exceeding Objective	Percent of Observations Exceeding Objective	Number of Observations Exceeding Objective	Percent of Observations Exceeding Objective	Number of Observations Exceeding Objective	Percent of Observations Exceeding Objective
Ag	0	0	1	9	0	0
As	0	0	0	0	0	0
Cd	1	9	0	0	0	0
Cr	0	0	0	0	0	0
Cu	1	9	0	0	0	0
Fe	4	36	0	0	0	0
Hg	0	0	0	0	2	9
Ni	0	0	0	0	0	0
Pb	0	0	0	0	0	0
Se	9	82	9	82	1	4
Zn	0	0	0	0	0	0

[1]Rossmann (1982).

Table 163. Toxicity unit results for the waters of Lakes Erie, Michigan, and Huron.

		Lake Erie		Lake Michigan		Lake Huron[1]	
Metal	Water Quality Objective (O_i)[1]	Observed Concentration (M_i)[1]	M_i/O_i	Observed Concentration (M_i)[1]	M_i/O_i	Observed Concentration (M_i)[2]	M_i/O_i
Ag	0.1	0.035	0.35	0.057	0.57	0.0090	0.090
As	50.	0.43	0.0086	0.69	0.014	0.21	0.0042
Cd	0.2	0.096	0.48	0.044	0.22	0.015	0.075
Cr	50.	0.39	0.0078	0.68	0.014	0.13	0.0026
Cu	5.0	1.8	0.36	0.39	0.078	0.40	0.080
Fe	300.	100.	0.33	75.	0.25	4.8	0.016
Hg	0.2[3]	0.024	0.12	0.045	0.22	0.0042	0.021
Ni	25.	1.1	0.044	25.	0.024	0.54	0.022
Pb	5.0[4]	0.34	0.068	0.25	0.050	0.022	0.0073
Se	1.0[5]	2.1	2.1	2.7	2.7	0.48	0.48
Zn	30.	1.2	0.040	0.59	0.020	0.29	0.010
Toxicity Unit ($\sum_{n=1}^{i} M_i/O_i$)			3.91		4.16		0.808

[1]Median (μg/L)
[2]Data from Rossmann (1982).
[3]Filtered sample.
[4]3.0 μg/L for Lake Huron.
[5]Recommended objective.

Committee 1980). Even if the current water quality objective for selenium (10 μg/L) is used, the toxicity unit for Lakes Erie and Michigan still exceeds 1.0, and selenium still significantly contributes to each lake's calculated toxicity unit. By comparison, the toxicity unit for Lake Huron does not exceed 1.0, and selenium is the only significant contributor. Metals which contribute significantly to each lake's toxicity unit should be carefully monitored. Special emphasis should be placed on monitoring selenium.

SUMMARY

Relative to Lake Huron, both Lakes Erie and Michigan have elevated trace metal concentrations. Within Lake Erie, resuspension of sediments contributes significantly to observed total metal concentrations, especially in the western basin. Most historical data are of questionable quality. Their utilization for describing changes in metals with time is very limited. All trends derived must be used with caution, especially for assessing the changing health of a Great Lake. In Lake Erie, total As, Be, Cr, and Hg and dissolved V concentrations appear to be decreasing, and total Ba and dissolved Mo concentrations appear to be increasing (Table 164). In Lake Michigan, dissolved Ag, Al, Cr, Cu, and Hg appear to be decreasing, while dissolved Sb, Se, and V appear to be increasing (Table 164).

On occasion, Lake Erie Cd, Cu, Fe, and Se and Lake Michigan Ag and Se concentrations exceeded Water Quality Agreement Objectives. In both lakes, the recommended selenium objective was exceeded in 82% of the samples analyzed. For Lake Erie, Ag, Cd, Cu, Fe, and Se significantly contributed to the calculated toxicity unit. For Lake Michigan, Ag, Cd, Fe, Hg, and Se significantly

Table 164. Summary of possible metal trends in the waters of Lakes Erie and Michigan.

Metal	Lake Erie Increase	Lake Erie Decrease	Lake Erie Unknown	Lake Michigan Increase	Lake Michigan Decrease	Lake Michigan Unknown
Total Ag			x			x
Dissolved Ag			x		x	
Total Al			x			x
Dissolved Al			x		x	
Total As		x				x
Dissolved As			x			x
Total Ba	x					x
Dissolved Ba			x			x
Total Be		x				x
Dissolved Be			x			x
Total Bi			x			x
Dissolved Bi			x			x
Total Cd			x			x
Dissolved Cd			x			x
Total Co			x			x
Dissolved Co			x			x
Total Cr		x				x
Dissolved Cr			x		x	
Total Cu			x			x
Dissolved Cu			x		x	
Total Fe			x			x
Dissolved Fe			x			x
Total Hg		x				x
Dissolved Hg			x		x	
Total Li			x			x
Dissolved Li			x			x
Total Mn			x			x
Dissolved Mn			x			x
Total Mo			x			x
Dissolved Mo	x					x
Total Ni			x			x
Dissolved Ni			x			x
Total Pb			x			x
Dissolved Pb			x			x
Total Sb			x			x
Dissolved Sb			x	x		
Total Se			x			x
Dissolved Se			x	x		
Total Sn			x			x
Dissolved Sn			x			x
Total Sr			x			x
Dissolved Sr			x			x
Total V			x			x
Dissolved V		x		x		
Total Zn			x			x
Dissolved Zn			x			x

contributed to this unit. The high occurrence of analyzed samples exceeding the recommended selenium objective and selenium's highly significant contribution to the calculated toxicity units warrant careful monitoring of this metal.

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APPENDIX

TRACE METAL CONCENTRATIONS IN

GREAT LAKES WATERS DURING 1981

Table 1. Silver concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	0.078	0.043
Ontario	WS-I	12	0.061	—
Erie	5	1	0.039	0.038
Erie	15	1	0.040	0.026
Erie	18	1	0.036	0.030
Erie	52	1	0.035	0.028
Erie	55	1	0.050	0.0077
Erie	57	1	0.033	0.025
Erie	61	1	0.024	0.0080
Erie	73	1	0.021	0.020 W
Erie	78	1	0.019 W	0.017 W
Erie	78	1	0.019 W	0.038
Erie	79	1	0.039	0.048
Huron	45	1	0.0076	0.011
Green Bay, Lake Michigan	41	1	0.058	0.039
Green Bay, Lake Michigan	42	1	0.059	0.047
Green Bay, Lake Michigan	43	1	0.061	0.069
Michigan	1	1	0.046	0.043
Michigan	6	1	0.074	0.069
Michigan	18	1	0.12	0.050
Michigan	27	1	0.057	0.052
Michigan	27	1	0.048	0.059
Michigan	41	1	0.050	0.054
Michigan	57	1	0.053	0.050
Michigan	72	1	0.046	0.049

W = Below the limit of detection.

Table 2. Aluminum concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	11. (0.42)	53. (0.071)
Ontario	WS-I	12	8.7 (0.74)	--
Erie	5	1	77. (4.6)	9.7 (0.64)
Erie	15	1	40. (2.3)	22. (0.92)
Erie	18	1	52. (0.99)	36. (2.4)
Erie	52	1	1200. (7.1)	12. (0.50)
Erie	55	1	5100. (21.)	56. (1.6)
Erie	57	1	5300. (42.)	26. (0.14)
Erie	61	1	2100. (97.)	60. (0.57)
Erie	73	1	20. (2.3)	3.2 (0.21)
Erie	78	1	190. (1.2)	12. (2.8)
Erie	78	1	180. (1.4)	8.5 (0.32)
Erie	79	1	97. (2.8)	24. (0.57)
Huron	45	1	46. (0.14)	9.1 (1.6)
Green Bay, Lake Michigan	41	1	63. (6.2)	21. (1.3)
Green Bay, Lake Michigan	42	1	90. (5.1)	8.1 (1.2)
Green Bay, Lake Michigan	43	1	59. (2.3)	3.2 (0.035)
Michigan	1	1	41. (1.3)	8.7 (0.035)
Michigan	6	1	16. (0.14)	8.2 (0.44)
Michigan	18	1	7.6 (2.5)	1.1 (0.35)
Michigan	27	1	8.3 (1.6)	0.72 (0.23) T
Michigan	27	1	1.7 (0.25)	0.79 (0.19) T
Michigan	41	1	33. (0.28)	89. (1.1)
Michigan	57	1	50. (2.3)	7.8 (0.87)
Michigan	72	1	40. (2.1)	3.8 (0.38)

T = Below the criterion of detection.

Table 3. Arsenic concentrations in Great Lakes waters (µg/L).

Lake	Station	Depth(m)	Total	0.5 µm Filtered
Ontario	WS-1	1	0.50	0.30
Ontario	WS-I	12	0.62	--
Erie	5	1	0.30	0.28
Erie	15	1	0.32	0.12 W
Erie	18	1	0.28	0.44
Erie	52	1	0.37	0.28 W
Erie	55	1	0.52	0.42
Erie	57	1	0.39	0.20 W
Erie	61	1	0.92	0.43 W
Erie	73	1	0.43	0.22 W
Erie	78	1	0.54	0.52
Erie	78	1	0.78	0.80
Erie	79	1	0.54	0.46 W
Huron	45	1	0.0 W	0.70
Green Bay, Lake Michigan	41	1	1.3	0.83
Green Bay, Lake Michigan	42	1	0.99	0.84
Green Bay, Lake Michigan	43	1	0.95	1.2
Michigan	1	1	0.48	0.50
Michigan	6	1	0.65	1.0
Michigan	18	1	0.67	0.46
Michigan	27	1	0.52	0.65
Michigan	27	1	0.54	0.42
Michigan	41	1	0.69	0.52
Michigan	57	1	0.90	1.1
Michigan	72	1	1.0	0.79

W = Below the limit of detection.

Table 4. Barium concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	47. (0.55)	53. (0.35)
Ontario	WS-I	12	--	--
Erie	5	1	49. (1.1)	51. (0.0)
Erie	15	1	50. (0.071)	50. (0.42)
Erie	18	1	48. (0.78)	52. (0.071)
Erie	52	1	54. (0.071)	46. (0.36)
Erie	55	1	57. (0.57)	44. (0.071)
Erie	57	1	58. (0.55)	41. (1.6)
Erie	61	1	50. (4.1)	42. (0.0)
Erie	73	1	52. (0.21)	48. (0.95)
Erie	78	1	54. (0.64)	48. (0.42)
Erie	78	1	53. (1.6)	48. (0.14)
Erie	79	1	47. (0.071)	52. (1.1)
Huron	45	1	37. (2.2)	37. (0.0)
Green Bay, Lake Michigan	41	1	49. (2.3)	47. (0.15)
Green Bay, Lake Michigan	42	1	44. (0.0)	49. (6.5)
Green Bay, Lake Michigan	43	1	46. (0.14)	44. (3.2)
Michigan	1	1	43. (0.094)	46. (5.4)
Michigan	6	1	49. (1.2)	52. (0.0)
Michigan	18	1	43. (0.20)	46. (5.3)
Michigan	27	1	45. (0.96)	48. (0.42)
Michigan	27	1	41. (0.85)	41. (1.3)
Michigan	41	1	41. (0.49)	43. (6.1)
Michigan	57	1	48. (3.1)	50. (0.25)
Michigan	72	1	48. (1.6)	46. (0.50)

Table 5. Beryllium concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	0.12	0.014
Ontario	WS-I	12	0.085	—
Erie	5	1	0.083	0.016
Erie	15	1	0.013	0.017
Erie	18	1	0.022	0.019
Erie	52	1	0.13	0.017
Erie	55	1	0.20	0.017
Erie	57	1	0.22	0.014
Erie	61	1	0.058	—
Erie	73	1	0.021	0.020
Erie	78	1	0.032	0.011
Erie	78	1	0.022	0.017
Erie	79	1	0.014	0.026
Huron	45	1	0.022	0.013
Green Bay, Lake Michigan	41	1	0.070	0.018
Green Bay, Lake Michigan	42	1	0.065	0.0097
Green Bay, Lake Michigan	43	1	0.021	0.0081
Michigan	1	1	0.022	0.016
Michigan	6	1	0.016	0.011 W
Michigan	18	1	0.019	0.0094 W
Michigan	27	1	0.0096	0.0096 W
Michigan	27	1	0.015	0.0079 W
Michigan	41	1	0.0081	0.0066
Michigan	57	1	0.013	0.0090
Michigan	72	1	0.013	0.016

W = Below the limit of detection.

Table 6. Bismuth concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	1.1 (0.0)	1.4 (0.040)
Ontario	WS-I	12	0.70 (0.076)	--
Erie	5	1	1.0 (0.091)	0.80 (0.0085)
Erie	15	1	1.5 (0.23)	1.9 (0.0)
Erie	18	1	1.6 (0.11)	1.1 (0.18)
Erie	52	1	0.27 (0.020)	0.67 (0.0064)
Erie	55	1	0.24 (0.038) T	0.69 (0.0092)
Erie	57	1	0.28 (0.0092)	0.31 (0.076)
Erie	61	1	0.59 (0.13)	0.85 (0.024)
Erie	73	1	0.58 (0.029)	0.36 (0.013)
Erie	78	1	0.44 (0.0057)	0.45 (0.022)
Erie	78	1	0.45 (0.016)	0.68 (0.016)
Erie	79	1	1.2 (0.15)	1.5 (0.092)
Huron	45	1	0.94 (0.052)	0.86 (0.030)
Green Bay, Lake Michigan	41	1	0.35 (0.0064)	1.3 (0.13)
Green Bay, Lake Michigan	42	1	0.66 (0.038)	0.75 (0.0028)
Green Bay, Lake Michigan	43	1	0.61 (0.0099)	0.83 (0.013)
Michigan	1	1	0.80 (0.034)	0.79 (0.097)
Michigan	6	1	1.4 (0.28)	1.5 (0.40)
Michigan	18	1	0.77 (0.052)	0.78 (0.0085)
Michigan	27	1	0.67 (0.17)	0.67 (0.0092)
Michigan	27	1	0.79 (0.061)	0.69 (0.035)
Michigan	41	1	0.53 (0.017)	0.81 (0.035)
Michigan	57	1	1.3 (0.13)	1.1 (0.028)
Michigan	72	1	1.2 (0.049)	1.2 (0.046)

T = Below the criterion of detection.

Table 7. Calcium concentrations in Great Lakes waters (mg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	38.	36.
Ontario	WS-I	12	38.	--
Erie	5	1	35.	35.
Erie	15	1	35.	33.
Erie	18	1	36.	36.
Erie	52	1	32.	31.
Erie	55	1	31.	29.
Erie	57	1	31.	29.
Erie	61	1	30.	27.
Erie	73	1	34.	36.
Erie	78	1	34.	33.
Erie	78	1	34.	32.
Erie	79	1	36.	36.
Huron	45	1	24.	24.
Green Bay, Lake Michigan	41	1	34.	34.
Green Bay, Lake Michigan	42	1	35.	36.
Green Bay, Lake Michigan	43	1	35.	35.
Michigan	1	1	33.	33.
Michigan	6	1	33.	33.
Michigan	18	1	33.	33.
Michigan	27	1	34.	38.
Michigan	27	1	34.	34.
Michigan	41	1	34.	33.
Michigan	57	1	33.	31.
Michigan	72	1	32.	31.

Table 8. Cadmium concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	0.040 (0.0044)	0.068 (0.0018)
Ontario	WS-I	12	0.059 (0.0098)	--
Erie	5	1	0.042 (0.00021)	0.041 (0.00092)
Erie	15	1	0.081 (0.0013)	0.096 (0.010)
Erie	18	1	0.052 (0.0059)	0.065 (0.0063)
Erie	52	1	0.10 (0.0096)	0.10 (0.0028)
Erie	55	1	0.14 (0.0035)	0.067 (0.0028)
Erie	57	1	0.14 (0.0026)	0.045 (0.0052)
Erie	61	1	0.32 (0.0)	0.12 (0.023)
Erie	73	1	0.039 (0.0019)	0.041 (0.0016)
Erie	78	1	0.044 (0.00021)	0.044 (0.0042)
Erie	78	1	0.072 (0.0060)	0.085 (0.0022)
Erie	79	1	0.049 (0.0018)	0.074 (0.0045)
Huron	45	1	0.025 (0.00092)	0.041 (0.0044)
Green Bay, Lake Michigan	41	1	0.087	0.044 (0.00042)
Green Bay, Lake Michigan	42	1	0.048 (0.0049)	0.051 (0.00035)
Green Bay, Lake Michigan	43	1	0.044 (0.00057)	0.045 (0.00042)
Michigan	1	1	0.019 (0.0018)	0.050 (0.0018)
Michigan	6	1	0.029 (0.0027)	0.039 (0.00021)
Michigan	18	1	0.044 (0.0040)	0.046 (0.0013)
Michigan	27	1	0.048 (0.0014)	0.031 (0.00099)
Michigan	27	1	0.028 (0.0013)	0.027 (0.0015)
Michigan	41	1	0.038 (0.0020)	0.041 (0.0011)
Michigan	57	1	0.046 (0.014)	0.052 (0.0011)
Michigan	72	1	0.035 (0.0045)	0.19 (0.0078)

Table 9. Cobalt concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	0.067	0.078
Ontario	WS-I	12	0.073	--
Erie	5	1	0.058	0.11
Erie	15	1	0.096	0.10
Erie	18	1	0.10	0.099
Erie	52	1	0.20	0.090
Erie	55	1	0.85	0.090
Erie	57	1	0.84	0.045
Erie	61	1	0.070	0.0023 W
Erie	73	1	0.050	0.048
Erie	78	1	0.10	0.069
Erie	78	1	0.068	0.084
Erie	79	1	0.086	0.089
Huron	45	1	0.0019 W	0.0 W
Green Bay, Lake Michigan	41	1	0.091	0.062
Green Bay, Lake Michigan	42	1	0.10	0.093
Green Bay, Lake Michigan	43	1	0.090	0.083
Michigan	1	1	0.080	0.058
Michigan	6	1	0.092	0.049
Michigan	18	1	0.053	0.042
Michigan	27	1	0.038	0.0035
Michigan	27	1	0.057	0.035
Michigan	41	1	0.057	0.036
Michigan	57	1	0.064	0.049
Michigan	72	1	0.047	0.040

W = Below the limit of detection.

Table 10. Chromium concentrations in Great Lakes waters (µg/L).

Lake	Station	Depth(m)	Total	0.5 µm Filtered
Ontario	WS-1	1	0.067	0.078
Ontario	WS-I	12	0.073	--
Erie	5	1	0.058	0.11
Erie	15	1	0.096	0.10
Erie	18	1	0.10	0.99
Erie	52	1	0.20	0.090
Erie	55	1	0.85	0.090
Erie	57	1	0.84	0.045
Erie	61	1	0.070	0.0023 W
Erie	73	1	0.050	0.048
Erie	78	1	0.10	0.069
Erie	78	1	0.068	0.084
Erie	79	1	0.086	0.089
Huron	45	1	0.0019 W	0.0 W
Green Bay, Lake Michigan	41	1	0.091	0.062
Green Bay, Lake Michigan	42	1	0.10	0.093
Green Bay, Lake Michigan	43	1	0.090	0.083
Michigan	1	1	0.080	0.058
Michigan	6	1	0.092	0.049
Michigan	18	1	0.053	0.042
Michigan	27	1	0.038	0.035
Michigan	27	1	0.057	0.035
Michigan	41	1	0.057	0.036
Michigan	57	1	0.064	0.049
Michigan	72	1	0.047	0.040

W = Below the limit of detection.

Table 11. Copper concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	1.2 (0.056)	0.92 (0.083)
Ontario	WS-I	12	1.6 (0.26)	--
Erie	5	1	2.6 (0.044)	1.7 (0.035)
Erie	15	1	1.6 (0.13)	1.4 (0.021)
Erie	18	1	2.1 (0.067)	1.4 (0.012)
Erie	52	1	1.8 (0.15)	0.56 (0.11)
Erie	55	1	2.3 (0.071)	0.89 (0.0057)
Erie	57	1	1.8 (0.035)	0.46 (0.013)
Erie	61	1	5.0 (0.021)	1.1 (0.089)
Erie	73	1	0.84 (0.044)	0.33 (0.042)
Erie	78	1	0.61 (0.032)	0.38 (0.0046)
Erie	78	1	1.5 (0.014)	0.43 (0.033)
Erie	79	1	1.1 (0.030)	0.70 (0.0095)
Huron	45	1	0.33 (0.044)	0.32 (0.032)
Green Bay, Lake Michigan	41	1	0.31 (0.023)	0.66 (0.017)
Green Bay, Lake Michigan	42	1	0.16 (0.11)	0.32 (0.010)
Green Bay, Lake Michigan	43	1	0.55 (0.079)	0.36 (0.015)
Michigan	1	1	0.58 (0.062)	0.28 (0.0057)
Michigan	6	1	0.35 (0.0071)	1.2 (0.17)
Michigan	18	1	0.22 (0.0)	0.32 (0.060)
Michigan	27	1	0.59 (0.043)	0.34 (0.052)
Michigan	27	1	0.72 (0.040)	0.26 (0.058)
Michigan	41	1	0.39 (0.039)	0.37 (0.066)
Michigan	57	1	0.42 (0.0)	0.19 (0.0)
Michigan	72	1	0.19 (0.0)	0.32 (0.0092)

Table 12. Iron concentrations in Great Lakes waters ($\mu g/L$).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	7.6 (0.085)	16. (0.50)
Ontario	WS-I	12	4.8 (0.17)	—
Erie	5	1	42. (1.3)	12. (0.15)
Erie	15	1	37. (1.7)	13. (1.9)
Erie	18	1	47. (2.6)	14. (1.6)
Erie	52	1	710. (12.)	9.4 (0.26)
Erie	55	1	1100. (12.)	41. (2.7)
Erie	57	1	1500. (64.)	36. (2.0)
Erie	61	1	1400. (170.)	20. (0.80)
Erie	73	1	37. (0.64)	5.3 (0.31)
Erie	78	1	100. (4.1)	7.9 (0.23)
Erie	78	1	120. (4.4)	4.1 (0.42)
Erie	79	1	37. (2.6)	17. (1.1)
Huron	45	1	70. (1.1)	4.4 (0.16)
Green Bay, Lake Michigan	41	1	54. (0.35)	2.5 (0.071)
Green Bay, Lake Michigan	42	1	76. (2.3)	6.2 (0.29)
Green Bay, Lake Michigan	43	1	93. (2.0)	4.2 (0.16)
Michigan	1	1	27. (2.3)	3.3 (0.15)
Michigan	6	1	15. (0.0)	1.8 (0.042)
Michigan	18	1	6.8 (0.23)	0.74 (0.28) T
Michigan	27	1	4.5 (0.23)	0.46 (0.18) T
Michigan	27	1	3.5 (0.0)	0.68 (0.014) T
Michigan	41	1	16. (0.21)	28. (1.9)
Michigan	57	1	48. (1.3)	4.3 (0.38)
Michigan	72	1	19. (0.35)	1.2 (0.064) T

T = Below criterion of detection.

Table 13. Mercury concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	--	--
Ontario	WS-I	12	--	--
Erie	5	1	0.12	0.056
Erie	15	1	0.00030 T	0.060
Erie	18	1	0.018	0.0081 T
Erie	52	1	0.012 T	0.0081 T
Erie	55	1	0.035	0.044
Erie	57	1	0.031	0.072
Erie	61	1	0.041	-0.0008 T
Erie	73	1	0.0062 T	0.017 T
Erie	78	1	0.14	0.011 T
Erie	78	1	0.034	0.024 T
Erie	79	1	0.033	0.080
Huron	45	1	--	--
Green Bay, Lake Michigan	41	1	0.011 T	0.018 T
Green Bay, Lake Michigan	42	1	0.069	0.067
Green Bay, Lake Michigan	43	1	0.090	0.034
Michigan	1	1	0.045	0.010 T
Michigan	6	1	0.030	0.048
Michigan	18	1	0.11	0.053
Michigan	27	1	0.0075 T	0.12
Michigan	27	1	0.043	0.049
Michigan	41	1	0.076	0.050
Michigan	57	1	0.057	-0.00060 T
Michigan	72	1	0.043	0.034

T = Below criterion of detection.

Table 14. Potassium concentrations in Great Lakes waters (mg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	1.3	1.3
Ontario	WS-I	12	1.3	--
Erie	5	1	1.2	1.1
Erie	15	1	1.2	1.2
Erie	18	1	1.2	1.1
Erie	52	1	1.2	1.0
Erie	55	1	1.6	1.2
Erie	57	1	1.7	1.2
Erie	61	1	1.4	0.99
Erie	73	1	1.2	1.1
Erie	78	1	1.2	1.2
Erie	78	1	1.2	1.2
Erie	79	1	1.2	1.1
Huron	45	1	0.76	0.71
Green Bay, Lake Michigan	41	1	1.0	1.0
Green Bay, Lake Michigan	42	1	1.1	1.1
Green Bay, Lake Michigan	43	1	1.2	1.2
Michigan	1	1	1.1	1.0
Michigan	6	1	1.0	1.0
Michigan	18	1	1.1	1.1
Michigan	27	1	1.1	1.0
Michigan	27	1	1.1	1.0
Michigan	41	1	1.0	1.0
Michigan	57	1	1.0	1.0
Michigan	72	1	0.89	0.89

Table 15. Lithium concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	2.4 (0.028)	2.6 (0.021)
Ontario	WS-I	12	2.1 (0.047)	--
Erie	5	1	1.9 (0.047)	1.8 (0.046)
Erie	15	1	1.8 (0.015)	1.7 (0.015)
Erie	18	1	2.0 (0.035)	2.0 (0.035)
Erie	52	1	2.8 (0.032)	1.3 (0.071)
Erie	55	1	3.4 (0.080)	1.2 (0.015)
Erie	57	1	3.1 (0.15)	1.1 (0.032)
Erie	61	1	3.3 (0.071)	1.9 (0.050)
Erie	73	1	1.7 (0.014)	1.6 (0.050)
Erie	78	1	2.0 (0.012)	1.5 (0.028)
Erie	78	1	1.7 (0.078)	1.8 (0.031)
Erie	79	1	2.1 (0.025)	2.0 (0.0058)
Huron	45	1	1.2 (0.028)	1.3 (0.080)
Green Bay, Lake Michigan	41	1	2.5 (0.028)	2.5 (0.12)
Green Bay, Lake Michigan	42	1	1.4 (0.071)	1.3 (0.032)
Green Bay, Lake Michigan	43	1	1.9 (0.021)	2.3 (0.017)
Michigan	1	1	2.5 (0.032)	1.7 (0.071)
Michigan	6	1	2.0 (0.014)	2.6 (0.021)
Michigan	18	1	1.5 (0.050)	1.6 (0.036)
Michigan	27	1	2.2 (0.0)	2.2 (0.026)
Michigan	27	1	2.2 (0.040)	2.2 (0.017)
Michigan	41	1	2.5 (0.020)	2.6 (0.010)
Michigan	57	1	2.6 (0.053)	2.3 (0.21)
Michigan	72	1	1.9 (0.051)	1.7 (0.078)

Table 16. Magnesium concentrations in Great Lakes waters (mg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	10.	10.
Ontario	WS-I	12	11.	--
Erie	5	1	10.	9.7
Erie	15	1	9.9	9.7
Erie	18	1	11.	10.
Erie	52	1	11.	10.
Erie	55	1	10.	10.
Erie	57	1	11.	9.7
Erie	61	1	10.	9.5
Erie	73	1	11.	11.
Erie	78	1	11.	10.
Erie	78	1	11.	10.
Erie	79	1	11.	10.
Huron	45	1	9.3	9.3
Green Bay, Lake Michigan	41	1	15.	15.
Green Bay, Lake Michigan	42	1	15.	15.
Green Bay, Lake Michigan	43	1	16.	16.
Michigan	1	1	15.	15.
Michigan	6	1	15.	15.
Michigan	18	1	15.	15.
Michigan	27	1	14.	14.
Michigan	27	1	14.	14.
Michigan	41	1	15.	15.
Michigan	57	1	14.	14.
Michigan	72	1	13.	13.

Table 17. Manganese concentrations in Great Lakes waters ($\mu g/L$).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	0.40 (0.0064)	0.13 (0.013)
Ontario	WS-I	12	0.39 (0.0042)	—
Erie	5	1	3.4 (0.11)	0.18 (0.0076)
Erie	15	1	2.3 (0.095)	0.45 (0.0050)
Erie	18	1	1.5 (0.014)	0.56 (0.066)
Erie	52	1	44. (0.72)	0.13 (0.014)
Erie	55	1	52. (0.10)	0.56 (0.028)
Erie	57	1	48. (0.14)	0.48 (0.012)
Erie	61	1	31. (0.97)	0.23 (0.0085) W
Erie	73	1	8.9 (0.078)	0.32 (0.0071)
Erie	78	1	12. (0.17)	0.37 (0.027)
Erie	78	1	13. (0.21)	0.30 (0.0047)
Erie	79	1	6.3 (0.10)	0.48 (0.017)
Huron	45	1	1.4 (0.031)	0.22 (0.092)
Green Bay, Lake Michigan	41	1	13. (0.55)	0.18 (0.0087)
Green Bay, Lake Michigan	42	1	31. (0.93)	0.91 (0.0021)
Green Bay, Lake Michigan	43	1	54. (0.31)	0.87 (0.024)
Michigan	1	1	0.25 (0.011)	0.10 (0.011)
Michigan	6	1	0.39 (0.0093)	0.11 (0.0020)
Michigan	18	1	0.27 (0.0021)	0.13 (0.0014)
Michigan	27	1	0.49 (0.043)	0.15 (0.0087)
Michigan	27	1	0.29 (0.0)	0.17 (0.0028)
Michigan	41	1	0.52 (0.012)	0.24 (0.014)
Michigan	57	1	1.9 (0.031)	0.15 (0.020)
Michigan	72	1	0.81 (0.0064)	0.034 (0.0087) W

Table 18. Molybdenum concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	2.8 (0.071)	1.9 (0.12)
Ontario	WS-I	12	1.8 (0.050)	--
Erie	5	1	2.3 (0.33)	1.6 (0.048)
Erie	15	1	2.1 (0.26)	1.7 (0.087)
Erie	18	1	2.0 (0.0)	1.8 (0.18)
Erie	52	1	1.1 (0.091)	1.4 (0.053)
Erie	55	1	1.4 (0.22)	1.5 (0.064)
Erie	57	1	0.86 (0.16)	0.94 (0.033)
Erie	61	1	1.2 (0.014)	1.3 (0.035)
Erie	73	1	1.2 (0.042)	1.3 (0.023)
Erie	78	1	1.2 (0.032)	1.5 (0.060)
Erie	78	1	1.5 (0.14)	1.4 (0.070)
Erie	79	1	2.2 (0.035)	1.8 (0.20)
Huron	45	1	0.89 (0.10)	0.62 (0.070)
Green Bay, Lake Michigan	41	1	1.2 (0.057)	1.2 (0.012)
Green Bay, Lake Michigan	42	1	0.76 (0.0050)	1.0 (0.11)
Green Bay, Lake Michigan	43	1	0.76 (0.0050)	1.0 (0.15)
Michigan	1	1	0.99 (0.0092)	1.3 (0.049)
Michigan	6	1	1.2 (0.015)	1.1 (0.042)
Michigan	18	1	0.81 (0.041)	1.4 (0.057)
Michigan	27	1	1.8 (0.014)	1.4 (0.070)
Michigan	27	1	1.0 (0.028)	1.3 (0.021)
Michigan	41	1	0.93 (0.029)	1.1 (0.17)
Michigan	57	1	1.3 (0.035)	1.4 (0.028)
Michigan	72	1	1.2 (0.010)	1.3 (0.085)

Table 19. Sodium concentrations in Great Lakes waters (mg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	13.	12.
Ontario	WS-I	12	12.	--
Erie	5	1	9.4	9.1
Erie	15	1	9.1	9.0
Erie	18	1	9.3	9.2
Erie	52	1	7.2	7.0
Erie	55	1	6.2	6.1
Erie	57	1	5.1	4.9
Erie	61	1	6.2	5.8
Erie	73	1	8.4	8.4
Erie	78	1	8.6	8.4
Erie	78	1	8.6	8.4
Erie	79	1	8.8	8.8
Huron	45	1	3.2	3.2
Green Bay, Lake Michigan	41	1	4.9	4.9
Green Bay, Lake Michigan	42	1	5.3	5.2
Green Bay, Lake Michigan	43	1	5.8	5.8
Michigan	1	1	5.0	5.0
Michigan	6	1	5.2	5.1
Michigan	18	1	5.0	5.0
Michigan	27	1	5.0	5.0
Michigan	27	1	5.0	5.0
Michigan	41	1	4.8	5.0
Michigan	57	1	5.0	4.9
Michigan	72	1	4.6	4.4

Table 20. Nickel concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	1.6 (0.0071)	1.5 (0.099)
Ontario	WS-I	12	0.98 (0.024)	--
Erie	5	1	0.80 (0.018)	1.3 (0.035)
Erie	15	1	1.4 (0.021)	1.2 (0.028)
Erie	18	1	0.85 (0.0050)	1.5 (0.19)
Erie	52	1	1.5 (0.029)	1.6 (0.0058)
Erie	55	1	1.8 (0.028)	1.7 (0.071)
Erie	57	1	2.3 (0.057)	1.1 (0.021)
Erie	61	1	4.6 (0.0071)	1.8 (0.070)
Erie	73	1	1.1 (0.021)	1.3 (0.092)
Erie	78	1	1.0 (0.050)	1.1 (0.028)
Erie	78	1	1.0 (0.028)	1.0 (0.074)
Erie	79	1	0.80 (0.0092)	1.3 (0.064)
Huron	45	1	0.61 (0.030)	0.72 (0.014)
Green Bay, Lake Michigan	41	1	0.54 (0.016)	0.70 (0.0090)
Green Bay, Lake Michigan	42	1	0.87 (0.14)	0.34 (0.017)
Green Bay, Lake Michigan	43	1	0.59 (0.0)	0.75 (0.030)
Michigan	1	1	0.68 (0.062)	0.98 (0.018)
Michigan	6	1	0.79 (0.050)	0.74 (0.013)
Michigan	18	1	0.56 (0.018)	0.66 (0.016)
Michigan	27	1	0.45 (0.0)	0.56 (0.034)
Michigan	27	1	0.46 (0.014)	0.44 (0.027)
Michigan	41	1	0.60 (0.0)	0.52 (0.054)
Michigan	57	1	0.79 (0.0099)	0.64 (0.0)
Michigan	72	1	0.69 (0.0)	0.62 (0.0057)

Table 21. Lead concentrations in Great Lakes waters (µg/L).

Lake	Station	Depth(m)	Total	0.5 µm Filtered
Ontario	WS-1	1	0.14 (0.021)	0.15 (0.0059)
Ontario	WS-I	12	0.14 (0.033)	--
Erie	5	1	0.18 (0.0099)	0.22 (0.0014)
Erie	15	1	0.20 (0.051)	0.16 (0.073)
Erie	18	1	0.25 (0.027)	0.16 (0.050)
Erie	52	1	1.1 (0.099)	0.24 (0.00071)
Erie	55	1	1.7 (0.028)	0.50 (0.017)
Erie	57	1	2.4 (0.040)	0.17 (0.0050)
Erie	61	1	3.0 (0.078)	0.020 (0.0067) T
Erie	73	1	0.15 (0.022)	0.19 (0.013)
Erie	78	1	0.34 (0.042)	0.14 (0.013)
Erie	78	1	0.34 (0.0078)	0.15 (0.025)
Erie	79	1	0.21 (0.016)	0.43 (0.0050)
Huron	45	1	0.10 (0.0099) T	0.13 (0.0021)
Green Bay, Lake Michigan	41	1	0.24 (0.0248)	0.082 (0.038)
Green Bay, Lake Michigan	42	1	0.15 (0.016)	0.023 (0.0014) T
Green Bay, Lake Michigan	43	1	0.25 (0.0028)	0.11 (0.0061)
Michigan	1	1	0.36 (0.050)	0.27 (0.017)
Michigan	6	1	0.28 (0.057)	0.22 (0.013)
Michigan	18	1	0.38 (0.024)	0.22 (0.011)
Michigan	27	1	0.13 (0.018)	0.14 (0.0053)
Michigan	27	1	0.25 (0.045)	0.20 (0.014)
Michigan	41	1	0.17 (0.0042)	0.18 (0.034)
Michigan	57	1	0.48 (0.017)	0.10 (0.0042)
Michigan	72	1	0.19 (0.032)	0.053 (0.020)

T = Below the criterion of detection.

Table 22. Antimony concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	0.11	0.18
Ontario	WS-I	12	0.13	--
Erie	5	1	0.098	0.069
Erie	15	1	0.071	0.069
Erie	18	1	0.018 W	0.084
Erie	52	1	0.0 W	0.083
Erie	55	1	0.047	0.21
Erie	57	1	0.036 T	0.17
Erie	61	1	0.085	0.33
Erie	73	1	0.39	0.28
Erie	78	1	0.35	0.42
Erie	78	1	0.34	0.45
Erie	79	1	0.16	0.17
Huron	45	1	0.22	0.50
Green Bay, Lake Michigan	41	1	0.11	0.029 W
Green Bay, Lake Michigan	42	1	0.056	0.22
Green Bay, Lake Michigan	43	1	0.34	0.064
Michigan	1	1	0.25	0.23
Michigan	6	1	0.30	0.28
Michigan	18	1	0.27	0.27
Michigan	27	1	0.25	0.31
Michigan	27	1	0.32	0.31
Michigan	41	1	0.30	0.27
Michigan	57	1	0.19	0.20
Michigan	72	1	0.14	0.19

W = Below the limit of detection.
T = Below the criterion of detection.

Table 23. Selenium concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	1.3	1.9
Ontario	WS-I	12	2.8	--
Erie	5	1	4.2	1.8
Erie	15	1	2.1	3.6
Erie	18	1	2.2	3.2
Erie	52	1	1.0	2.4
Erie	55	1	1.9	2.7
Erie	57	1	0.63	1.5
Erie	61	1	0.0 W	1.1
Erie	73	1	1.8	2.5
Erie	78	1	2.5	3.0
Erie	78	1	2.5	2.0
Erie	79	1	3.5	4.0
Huron	45	1	0.99	0.87
Green Bay, Lake Michigan	41	1	0.86	1.7
Green Bay, Lake Michigan	42	1	1.5	3.5
Green Bay, Lake Michigan	43	1	0.90	1.8
Michigan	1	1	3.4	3.0
Michigan	6	1	4.5	3.7
Michigan	18	1	3.3	3.1
Michigan	27	1	3.0	3.2
Michigan	27	1	3.0	3.1
Michigan	41	1	2.7	2.3
Michigan	57	1	2.0	1.9
Michigan	72	1	2.6	1.7

W = Below the limit of detection.

Table 24. Tin concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	0.22 T	0.29 T
Ontario	WS-I	12	0.44	--
Erie	5	1	0.22 T	0.30 T
Erie	15	1	0.16 T	0.40 T
Erie	18	1	0.18 T	0.44 T
Erie	52	1	3.5	1.1
Erie	55	1	1.3	1.6
Erie	57	1	1.9	2.1
Erie	61	1	3.7	4.2
Erie	73	1	3.0	2.1
Erie	78	1	1.4	0.57
Erie	78	1	5.9	3.0
Erie	79	1	0.90	0.28 T
Huron	45	1	5.2	6.2
Green Bay, Lake Michigan	41	1	7.1	10.
Green Bay, Lake Michigan	42	1	1.6	1.7
Green Bay, Lake Michigan	43	1	1.8	1.9
Michigan	1	1	0.033 T	1.5
Michigan	6	1	3.3	9.1
Michigan	18	1	2.3	1.1
Michigan	27	1	3.7	0.29 T
Michigan	27	1	2.6	0.15 T
Michigan	41	1	0.85	0.62
Michigan	57	1	7.2	0.19 T
Michigan	72	1	7.3	1.5

T = Below the criterion of detection.

Table 25. Strontium concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	160.	170.
Ontario	WS-I	12	160.	--
Erie	5	1	140.	160.
Erie	15	1	160.	140.
Erie	18	1	140.	150.
Erie	52	1	130.	130.
Erie	55	1	150.	140.
Erie	57	1	120.	100.
Erie	61	1	110.	100.
Erie	73	1	160.	140.
Erie	78	1	150.	150.
Erie	78	1	140.	130.
Erie	79	1	150.	180.
Huron	45	1	94.	97.
Green Bay, Lake Michigan	41	1	110.	110.
Green Bay, Lake Michigan	42	1	120.	110.
Green Bay, Lake Michigan	43	1	120.	110.
Michigan	1	1	120.	110.
Michigan	6	1	110.	110.
Michigan	18	1	120.	120.
Michigan	27	1	120.	120.
Michigan	27	1	110.	110.
Michigan	41	1	120.	99.
Michigan	57	1	110.	87.
Michigan	72	1	100.	110.

Table 26. Vanadium concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	0.53	0.44
Ontario	WS-I	12	0.53	--
Erie	5	1	0.36	0.43
Erie	15	1	0.23	0.16
Erie	18	1	0.32	0.33
Erie	52	1	0.27	0.38
Erie	55	1	3.7	0.37
Erie	57	1	4.1	0.39
Erie	61	1	1.8	0.10
Erie	73	1	0.41	0.23
Erie	78	1	0.64	0.35
Erie	78	1	0.46	0.31
Erie	79	1	0.42	0.39
Huron	45	1	0.11	0.11
Green Bay, Lake Michigan	41	1	0.65	0.23
Green Bay, Lake Michigan	42	1	0.81	0.77
Green Bay, Lake Michigan	43	1	1.2	0.81
Michigan	1	1	0.32	0.32
Michigan	6	1	0.26	0.23
Michigan	18	1	0.48	0.54
Michigan	27	1	0.56	0.45
Michigan	27	1	0.31	0.21
Michigan	41	1	0.62	0.51
Michigan	57	1	0.46	0.33
Michigan	72	1	0.26	0.23

Table 27. Zinc concentrations in Great Lakes waters (μg/L).

Lake	Station	Depth(m)	Total	0.5 μm Filtered
Ontario	WS-1	1	0.74 (0.031)	0.59 (0.023)
Ontario	WS-I	12	1.4 (0.19)	--
Erie	5	1	1.2 (0.0)	1.3 (0.028)
Erie	15	1	0.68 (0.0078)	0.57 (0.081)
Erie	18	1	0.96 (0.064)	1.1 (0.032)
Erie	52	1	4.5 (0.031)	2.4 (0.050)
Erie	55	1	17. (0.26)	4.0 (0.061)
Erie	57	1	18. (0.21)	0.71 (0.034)
Erie	61	1	24. (0.71)	3.2 (0.19)
Erie	73	1	1.1 (0.078)	0.49 (0.038)
Erie	78	1	1.1 (0.064)	0.32 (0.032)
Erie	78	1	2.2 (0.028)	2.3 (0.18)
Erie	79	1	0.55 (0.0)	1.4 (0.014)
Huron	45	1	0.56 (0.0028)	0.48 (0.014)
Green Bay, Lake Michigan	41	1	0.69 (0.033)	0.25 (0.0)
Green Bay, Lake Michigan	42	1	0.59 (0.022)	0.35 (0.030)
Green Bay, Lake Michigan	43	1	0.59 (0.017)	1.0 (0.10)
Michigan	1	1	0.49 (0.058)	0.48 (0.0)
Michigan	6	1	0.56 (0.11)	0.65 (0.051)
Michigan	18	1	0.74 (0.078)	0.41 (0.097)
Michigan	27	1	0.37 (0.058)	0.41 (0.081)
Michigan	27	1	0.75 (0.13)	0.56 (0.090)
Michigan	41	1	0.43 (0.031)	0.35 (0.055)
Michigan	57	1	1.1 (0.12)	0.61 (0.098)
Michigan	72	1	0.52 (0.030)	2.1 (0.023)